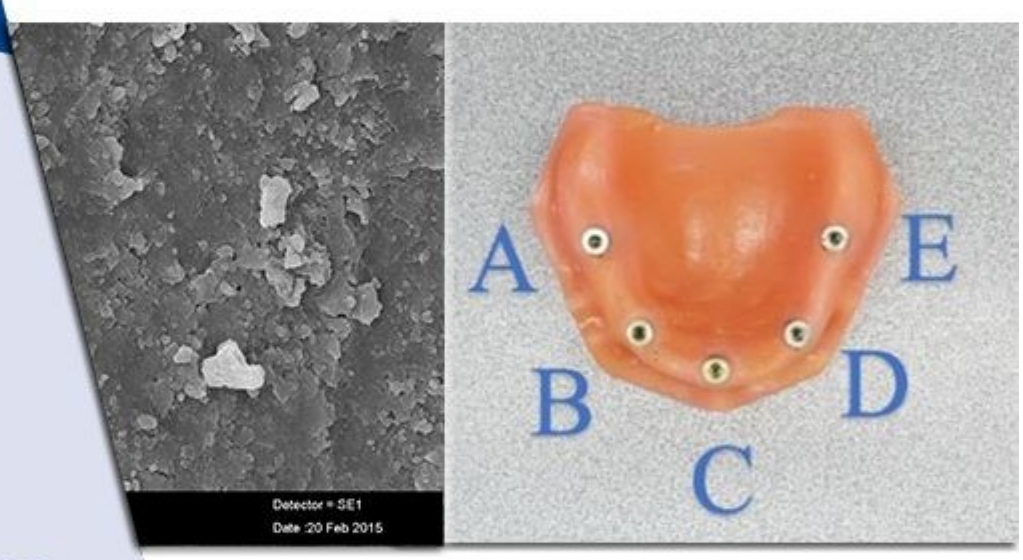
# Cumhuriyet Dental Journal




26 (1): 2023

Published By
Sivas Cumhuriyet University
http:// cdj.cumhuriyet.edu.tr

E-ISSN: 2146-2852
ISSN: 1302-5805

**Cumhuriyet Dental Journal**

*The Official Journal of the Sivas Cumhuriyet University Faculty of Dentistry. The first issue was published in 1998 and journal's name was changed as Cumhuriyet Dental Journal in 2010. Issues are published quarterly since 2018.*

**Aims and Scope**

Cumhuriyet Dental Journal (CDJ) is an international journal dedicated to the latest advancement of dentistry. The aim of this journal is to provide a platform for scientists and academicians all over the world to promote, share, and discuss various new issues and developments in different areas of dentistry.

CDJ publishes original research papers, reviews, and case reports within clinical dentistry, on all basic science aspects of structure, chemistry, developmental biology, physiology and pathology of relevant tissues, as well as on microbiology, biomaterials and the behavioral sciences as they relate to dentistry.

*Please visit http://dergipark.gov.tr/cumudj to see homepage and related information about CDJ.*

*ISSN 1302-5805*

*e-ISSN 2146-2852*

*Volume/26- Issue/1-2023*



Serap Bekis, Editorial Office, Faculty of Dentistry, Sivas Cumhuriyet University, 58140, Sivas, Turkey

e-mail: cdj@cumhuriyet.edu.tr Phone: +90 346 2191010 / 2730 (ext)

*INDEXING*

*Cumhuriyet Dental Journal: 2023; 26(1)*
ISSN: 1302-5805 e-ISSN 2146-2852

# CONTENTS

***ORIGINAL RESEARCH***

Cumhuriyet Dental Journal, 26(1): 1-7, 2023
DOI: https://doi.org/10.7126/cumudj.1105151

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 | Available online, ISSN: 1302-5805 e-ISSN: 2146-2852 | Publisher: Sivas Cumhuriyet Üniversitesi

# The Indicators of Molar Coefficients of the Chemical Elements in Dentin and their Correlation with Enamel

**Iryna I. Zabolotna[1,a], Olena S. Genzytska[1,b*], Oleksandr S. Zabolotnyi[2,c]**

[1] *Department of Internship of Doctors-Dentists, Faculty of Internship and Postgraduate Education, Donetsk national medical university, Liman, Ukraine*
[2] *Student of Faculty of Computer Sciences and Software Engineering, National Technical University «Kharkiv Polytechnic Institute», Kharkiv, Ukraine*
**Corresponding author*

**Research Article**

*History*

*Received: 18/04/2022*
*Accepted: 08/01/2023*



## ABSTRACT

***Objectives:*** Determination of molar coefficients of the chemical elements in dentin, their possible correlation with tooth enamel.

***Material and Methods:*** There were examined 29 clinically extracted teeth of both jaws and their longitudinal sections (12 clinically intact teeth, 10 teeth with wedge-shaped defects, 7 teeth with cervical caries) of the patients aged 25 to 54 with the help of JSM-6490 LV focused beam electron microscope (scanning) with system of energy-dispersive X-ray microanalysis. We have determined the chemical composition of 290 enamel areas and 235 dentin areas in the incisal region (tubercle), equator, cervical area as a percentage of the weight amounts of carbon, oxygen, calcium, phosphorus, sodium, magnesium, sulfur, chlorine, zinc, potassium, aluminum, we have identified their molar coefficients.

***Results:*** The chemical composition of dentin differed in the values of Na/Mg, Al/Zn, Mg/Ca, K/Na ($p \leq 0.05$) in all studied topographical regions of the samples. Higher values of Na/Mg and lower values of Al/Zn were identified in the teeth with cervical caries ($p \leq 0.05$). Correlation was found in dentin: inverse - between Ca/P and P/Ca, Mg/Ca and Na/Mg, Ca/Mg and Mg/Ca, Mg/P and Na/Mg, Mg/P and Ca/Mg, direct - between Ca/Mg and Na/Mg, Mg/P and Mg/Ca ($p \leq 0.05$). High correlation was determined between molar coefficients in enamel and dentin: Mg/Ca and Mg/P (direct), Ca/P and P/Ca (inverse), $p < 0.0001$.

***Conclusions:*** The differences in the indicators of molar coefficients in dentin, their correlation with enamel are probably associated with the peculiarities of the pathological processes in the cervical region and it requires further study.

***Key words:*** Teeth, Enamel, Dentin, Chemical Elements, Cervical Caries.

[a] myhelp200@gmail.com https://orcid.org/0000-0002-3284-0392
[b] blacky3000@ukr.net https://orcid.org/0000-0002-4694-8679
[c] sergzabolotny@gmail.com https://orcid.org/0000-0003-0291-2727

*How to Cite: Zabolotna I.I, Genzytska O.S., Zabolotnyi O. S. (2023) The Indicators of Molar Coefficients of the Chemical Elements in Dentin and their Correlation with Enamel, Cumhuriyet Dental Journal, 26(1):1-7.*

## Introduction

The onset of the pathology of dental hard tissues is generally considered that the lesions don't result from a single factor but they may be caused by a combination of some factors.[1] The effectiveness of its prevention depends on understanding the risk factors and how they interact and change in specific patients in course of time.[2] The content of the chemical elements in hard dental tissues is not a constant value but it dynamically changes under the influence of various reasons, one of which is damage of carious and non-carious genesis.[3,4] Dentin permeability can be increased because of the changes to the integrity of enamel and dentin through processes of trauma, decay and toothwear.[5] The amount of calcium has significant differences both in the structure of enamel and dentin in different types of pathology and it determines their development.[6] Dentin also had the characteristics of microwear which were more consistent with wear types than enamel.[7] Chemical dissolution of the components of both organic and inorganic matrix happens during an acidic attack or a typical demineralization regime. It is come about by the water content of enamel and dentin that facilitate acid diffusion in and mineral content out of the tooth. The areas of structural weakness which have been demineralized are also the objectives for the formation of caries. Bacteria can colonize tooth demineralized areas easily and, with a combination of their own acid formation, they can penetrate into dentin.[8] Previous studies confirmed the assumptions about the differences in the inorganic composition of enamel and dentin at various levels.[6,9,10] Significant differences were found in the content of sodium and zinc in dentin of the incisal region (tubercle) (IR), equator (E), cervical area (CA) depending on the presence and type of the pathology.[9] But taking into account the widespread occurrence of the coordinated effects of some chemical elements it is necessary to pay attention not only to their amount but also to the ratios that have a synergistic and antagonistic impact on various physiological parameters.[11] We have hypothesized that molar coefficients in dentin, their possible correlation with enamel may influence the

occurrence and progression of cervical defects in hard dental tissues. Therefore, this study is considered to be relevant to determine the integrated parameters under the conditions of the physiology of the oral cavity, establish their critical values in order to prevent the onset of the pathology.

The purpose of the study is to determine molar coefficients of the chemical elements in the dentin of clinically intact teeth, teeth with a wedge-shaped defect and cervical caries in IR, E, CA, identify their possible correlation with enamel.

## Material and Methods

Written informed consent was obtained from all subjects in compliance with Helsinki Declaration of the World Medical Association – Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects (1964-2008) as well as the order of the Ministry of Health of Ukraine No. 690 dated September 23, 2009. The work was approved by Bioethics Commission of Donetsk National Medical University (No 43, dated January 21, 2021).

We examined 29 teeth that were extracted from both jaws for some orthodontic indications and their longitudinal sections (12 clinically intact teeth, 10 teeth with wedge-shaped defects, 7 teeth with cervical caries) of the patients aged 25 to 54 with the help of a JSM-6490 LV focused beam electron microscope (scanning) with system of energy-dispersive X-ray microanalysis INCA Penta FETx3 (OXFORD Instruments, England) based on the previously described method.[9] Using the method of the peak to background ratio local mass fractions of chemical elements were calculated taking into consideration the corrections for atomic number, fluorescence and absorption, measured in normal mass percentage (normal mass %). The mineral composition of 290 enamel and 235 dentine areas in IR, E, CA has been identified as a percentage of the weight amounts of calcium, phosphorus, sodium, magnesium, sulfur, chlorine, zinc, potassium, and aluminum. The molar coefficients were calculated as the ratio of the amounts of chemical elements. We examined dentin at approximately the same distance from the enamel-dentin border.

To determine possible relationships between the chemical composition of enamel and dentin the correlation was identified in the following groups: Group I – teeth with a wedge-shaped defect and clinically intact hard tissues, Group II –teeth with cervical caries and clinically intact hard tissues, Group III – teeth with cervical pathology. The research was carried out at the base of Donetsk Institute of Physics and Technology of the National Academy of Sciences of Ukraine.

### *Statistical analysis*

Using the Statistica 12.0 computer program (3BA94C4ED07A) we carried out statistical analysis. We used the G*Power program to calculate the sample size. Replication measurements were averaged in one sample before statistical analysis. To check the presence of the relationship between the variables, the correlation analysis was performed (Pearson's parametric correlation method) based on the determination of the parametric Brave-Pearson coefficient (r) with the confidence level of 95%. Using Student's T-test we assessed the reliability of obtained results as well as the correlation between the indicators – based on Student's T-test using Z-test (Fisher's Z-test). The differences were thought to be statistically significant at $p \leq 0.05$. The significance of the differences between the groups was evaluated based on the analysis of variance.

## Results

The chemical composition of dentin in the area of IR samples was determined at the first stage (Table 1). Clinically intact teeth were characterized by higher molar coefficients of P/Ca, Al/Zn, K/Na and lower ones of Na/K ($p \leq 0.05$). The values of Al/Zn molar coefficient in dentin of intact samples were 4.5 and 1.5 times higher than in the samples with cervical caries and a wedge-shaped defect, respectively. Its indicators differed by 2 times depending on the type of the pathology of hard dental tissues ($p \leq 0.05$). The chemical composition of dentin of the samples with a carious process was characterized by higher values of the coefficients of Na/Mg, Ca/P, Ca/Mg ($p \leq 0.05$). The indicators of Na/Mg in the teeth with cervical caries were 10.7 and 4.7 times higher than in the teeth with a wedge-shaped defect and intact teeth, respectively. Na/Mg molar coefficient was 2.3 times higher in the group of clinically intact samples compared to the samples with non-carious cervical pathology (NCCL). The indicators of C/Mg in dentin of the teeth with caries were 2.7 and 2.2 times higher than those ones with a wedge-shaped defect and intact hard tissues, respectively.

The chemical composition of dentin of the samples in E region was studied at the next stage (Table 2). Dentin of clinically intact teeth was distinguished by higher values of molar coefficients of Al/Zn, Mg/Ca, Mg/P and lower values of Na/Mg, Ca/Mg, K/Na ($p \leq 0.05$). The indicators of Al/Zn in intact samples were 4 and 2 times higher than in the samples with cervical caries and a wedge-shaped defect, respectively. The indicators of Al/Zn differed 2 times depending on the type of cervical pathology ($p \leq 0.05$). Significant differences were identified in terms of the indicators of Na/Mg molar coefficient. Its values were 2.5 and 4.5 times higher in dentin of the samples with cervical caries than in the samples with a wedge-shaped defect and clinically intact hard tissues, respectively ($p \leq 0.05$). The teeth with a carious process had higher indicators of Ca/Mg molar coefficient: almost 2 times higher when compared with the teeth with NCCL and 3.8 times higher when compared with intact teeth. The molar coefficient of K/Na was 2.4 and 5 times higher in dentin of the samples of the teeth with a wedge-shaped defect when compared with the samples damaged by caries and intact teeth, respectively.

The results of determining the chemical composition of dentin in CA region are presented in Table 3. Examined parts of dentin in CA are presented in Figure 1.

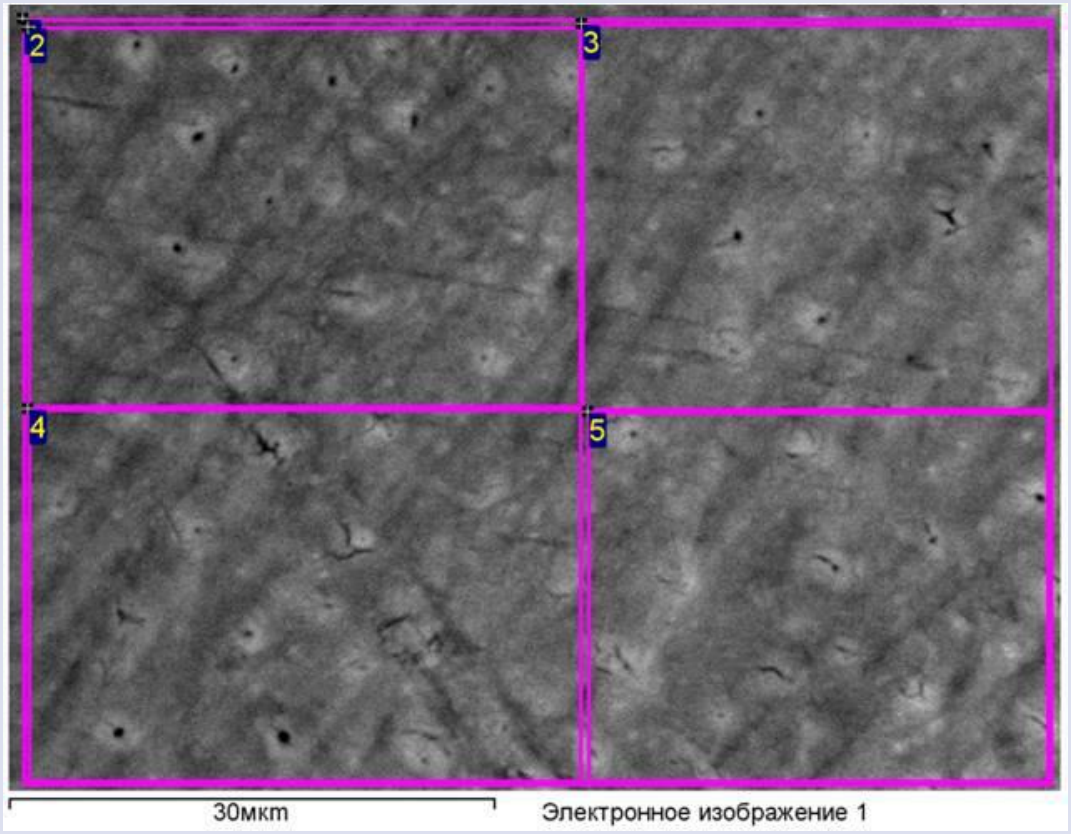



Figure 1-A. The sample with a wedge-shaped defect (magnification x30).

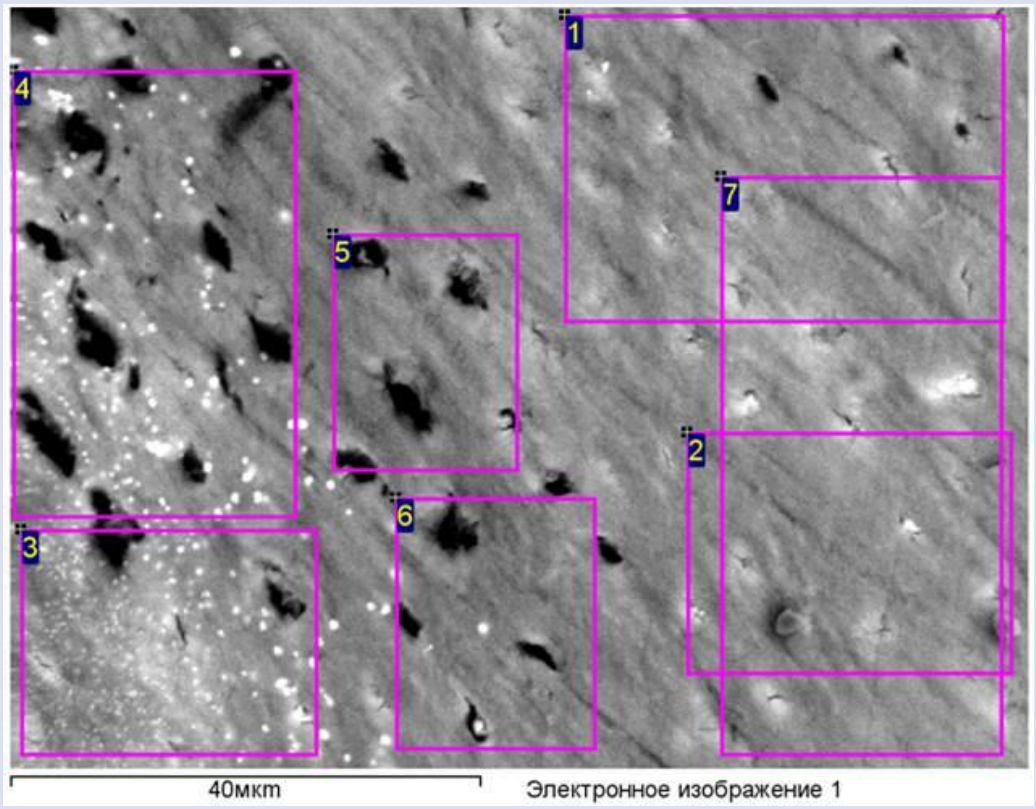



Figure 1-B. The sample with cervical caries (magnification x40).

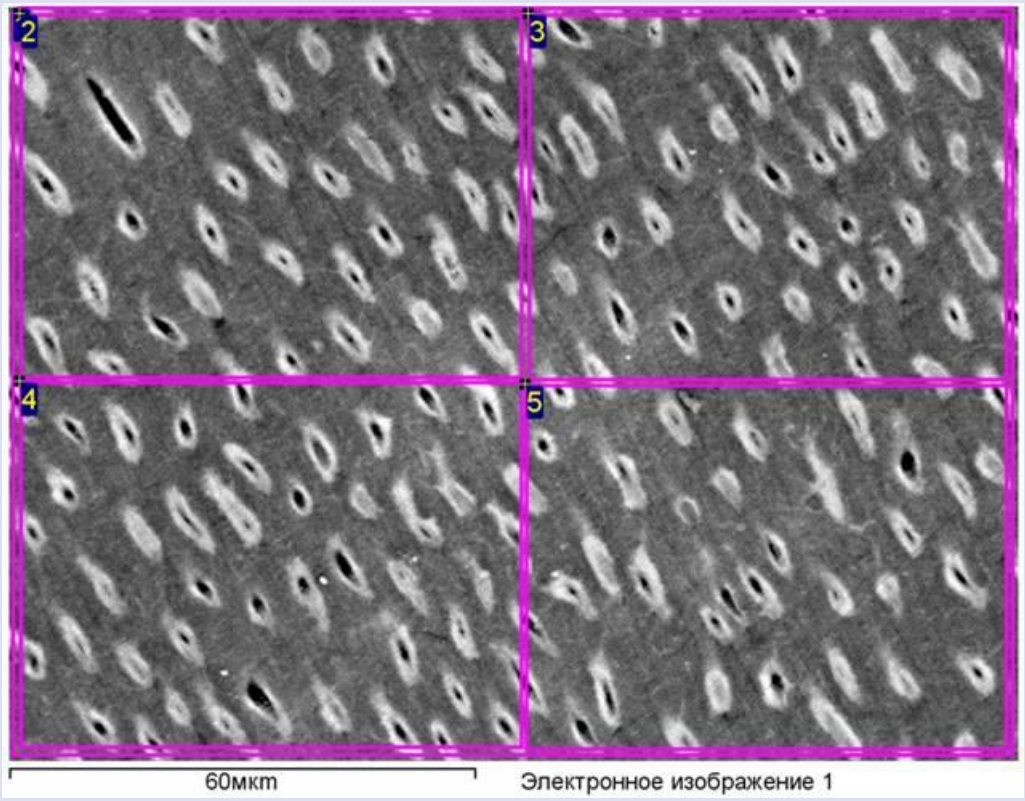



Figure 1-C. The sample of clinically intact teeth (magnification x60).

**Table 1.** The molar coefficients of chemical elements in dentin of IR

| Molar coefficients | Teeth with wedge-shaped defect mean±SD (*n*=21) | Teeth with cervical caries mean±SD (*n*=26) | Clinically intact teeth mean±SD (*n*=20) | *P-value* |
|---|---|---|---|---|
| Na/K | 53.103±44.934 | 74.014±38.785$^{\#}$ | 43.749±42.338$^{**}$ | 0.048* |
| Na/Mg | 0.846±0.225$^{\#**}$ | 9.035±10.951$^{\#}$ | 1.938±0.498$^{**}$ | <0.001* |
| Ca/P | 1.802±0.030$^{\#**}$ | 1.947±0.113 | 1.934±0,135 | <0.001* |
| P/Ca | 0.055±0.009$^{\#**}$ | 0.515±0.030 | 0.520±0.038 | <0.001* |
| Ca/Mg | 52.717±12.024$^{\#**}$ | 143.134±149.484$^{\#}$ | 64.267±22.035$^{**}$ | 0.003* |
| Ca/Cl | 294.962±126.626$^{**}$ | 189.292±263.410 | 214.443±129.909 | 0.188 |
| Al/Zn | 40.525±50.661$^{**}$ | 20.266±41.199$^{\#}$ | 62.591±50.172$^{**}$ | 0.014* |
| Mg/Ca | 0.020±0.004$^{**}$ | 0.015±0.009 | 0.017±0.006 | 0.043* |
| Mg/P | 0.036±0.008$^{**}$ | 0.028±0.018 | 0.034±0.013 | 0.144 |
| K/Na | 0.054±0.063$^{**}$ | 0.020±0.032$^{\#}$ | 0.058±0.051$^{**}$ | 0.018* |

*p* – the statistical significance of differences; *n* – number of dentin areas; * (p≤0.05); $^{\#}$ – the difference of intact teeth from dentin is statistically significant, p≤0.05; $^{**}$ – the difference of teeth with cervical caries from dentin is statistically significant, p≤0.05.

**Table 2.** The molar coefficients of chemical elements in dentin of E

| Molar coefficients | Teeth with wedge-shaped defect mean±SD (*n*=26) | Teeth with cervical caries mean±SD (*n*=41) | Clinically intact teeth mean±SD (*n*=26) | *P-value* |
|---|---|---|---|---|
| Na/K | 49.020±45.688 | 59.222±43.116 | 69.530±37.311 | 0.315 |
| Na/Mg | 2.539±3.568$^{**}$ | 6.255±7.5126$^{\#}$ | 1.385±0.386$^{**}$ | 0.005* |
| Ca/P | 1.992±0.138$^{\#}$ | 2.051±0.138 | 2.072±0.061 | 0.091 |
| P/Ca | 0.504±0.035$^{\#}$ | 0.490±0.034 | 0.483±0.014 | 0.078 |
| Ca/Mg | 84.479±29.760$^{\#**}$ | 165.158±160.578$^{\#}$ | 43.774±8.171$^{**}$ | <0.001* |
| Ca/Cl | 234.088±161.405$^{**}$ | 353.009±462.075 | 290.075±283.613 | 0.430 |
| Al/Zn | 35.145±48.867$^{\#**}$ | 17.281±38.459$^{\#}$ | 69.554±48.174$^{**}$ | <0,001* |
| Mg/Ca | 0.013±0.003$^{\#}$ | 0.015±0.012$^{\#}$ | 0.024±0.004$^{**}$ | <0.001* |
| Mg/P | 0.026±0.007$^{\#}$ | 0.029±0.023$^{\#}$ | 0.049±0.007$^{**}$ | <0.001* |
| K/Na | 0.091±0.115$^{\#**}$ | 0.038±0.043 | 0.018±0.025 | 0.003* |

*p – the statistical significance of differences; n – number of dentin areas; * (p≤0.05); $^{\#}$ – the difference of intact teeth from dentin is statistically significant, p≤0.05; $^{**}$ – the difference of teeth with cervical caries from dentin is statistically significant, p≤0.05.*

**Table 3.** The molar coefficients of chemical elements in dentin of CA

| Molar coefficients | Teeth with wedge-shaped defect mean±SD (*n*=26) | Teeth with cervical caries mean±SD (*n*=20) | Clinically intact teeth mean±SD (*n*=29) | *P-value* |
|---|---|---|---|---|
| Na/K | 50.0378±44.467$^{\#**}$ | 69.095±43.137 | 82.969±31.480 | 0.019* |
| Na/Mg | 2.638±4.672$^{\#**}$ | 10.177±6.390 | 9.811±23.608 | 0.13* |
| Ca/P | 1.791±0,143$^{\#**}$ | 1.945±0.161$^{\#}$ | 2.0599±0.065$^{**}$ | <0.001* |
| P/Ca | 0.562±0.044$^{\#**}$ | 0.518±0.047$^{\#}$ | 0.486±0.016$^{**}$ | <0.001* |
| Ca/Mg | 120.728±201.365$^{**}$ | 186.690±90.962 | 163.451±264.068 | 0.411 |
| Ca/Cl | 218.106±148.323$^{**}$ | 108.515±67.421 | 160.866±127.932 | 0.007* |
| Al/Zn | 35.200±48.358$^{**}$ | 0.970±1.018$^{\#}$ | 31.690±48.262$^{**}$ | 0.011* |
| Mg/Ca | 0.014±0.005$^{**}$ | 0.008±0.008 | 0.013±0.009 | 0.006* |
| Mg/P | 0.024±0.009$^{**}$ | 0.016±0.014$^{\#}$ | 0.027±0.017$^{**}$ | 0.009* |
| K/Na | 0.421±0.137$^{\#**}$ | 0.975±0.374 | 1.011±0.410 | <0.001* |

*p – the statistical significance of differences; n – number of dentin areas; * (p≤0.05);$^{\#}$ – the difference of intact teeth from dentin is statistically significant, p≤0.05; $^{**}$ – the difference of teeth with cervical caries from dentin is statistically significant, p≤0.05.*

Intact teeth had higher values of Na/K, Ca/P, Mg/P and K/Na (p≤0.05). The indicators of K/Na in their dentin were 2.4 times higher than in the samples with NCCL. Its indicators differed by 2.3 times in the groups of the teeth with a cervical pathology. Na/Mg coefficient was 3.9 times lower in the samples with a wedge-shaped defect than in the samples with cervical caries, and it was 3.7 times lower when compared with intact samples. Dentin of the teeth with NCCL differed from the teeth with carious process by 1.5 times lower values of Ca/Mg and 2 times higher values of Ca/Cl (p≤0.05). Significant differences were determined in Al/Zn-coefficient: its indicators in the group of the teeth with cervical caries were 36 and 32.7 times lower than in the groups of the teeth with NCCL and intact hard tissues, respectively.

Thus, the chemical composition of dentin in clinically intact specimens and with cervical pathology in all studied anatomical areas differed in the values of molar coefficients of Na/Mg, Al/Zn, Mg/Ca, K/Na (p≤0.05). There have been determined higher values of Na/Mg and lower values of Al/Zn (p≤0.05) in teeth with cervical caries.

The revealed correlations between the molar coefficients in dentin of the studied topographical areas, their nature are presented in Table 4. Correlation was determined: inverse - between Ca/P and P/Ca, Mg/Ca and Na/Mg, Ca/Mg and Mg/Ca, Mg/P and Na/Mg, Mg/P and Ca/Mg, direct - between Ca/Mg and Na/Mg, Mg/P and Mg/Ca (p≤0.05). High correlation was found between the molar coefficients in dentin and enamel: direct -Mg/Ca and Mg/P, inverse - Ca/P and P/Ca, p<0.0001 (Table 5).

**Table 4.** Correlation between the molar coefficients of dentin, r

| Molar coefficients | Area | Molar coefficients | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Na/Mg | | | Mg/P | | | Mg/Ca | | | Ca/P | | |
| | | group | | | | | | | | | | | |
| | | I | II | III | I | II | III | I | II | III | I | II | III |
| Ca/Mg | IR | 0.551* | 0.910* | 0.916* | -0.922* | -0.735* | -0.788* | -0.994* | -0.760* | -0.803* | | | |
| | E | 0.672* | 0.943* | 0.913* | -0.878* | -0.776* | -0.685* | -0.889* | -0.774* | -0.687* | | - | |
| | CA | 0.810* | 0.977* | 0.817* | -0.598* | -0.585* | -0.615* | -0.637* | -0.581* | -0.625* | | | |
| Mg/Ca | IR | -0.503 *p*=0.010 | -0.758* | -0.837* | 0.979* | 0.992* | 0.993* | | | | | | |
| | E | -0.408 *p*=0.008 | -0.684* | -0.586* | 0.992* | 0.996* | 0.995* | | - | | | - | |
| | CA | -0.484* | -0.470 *p*=0.004 | -0.765* | 0.978* | 0.994* | 0.993* | | | | | | |
| Mg/P | IR | -0.358* | -0.726* | -0.819* | | | | | | | | | |
| | E | -0.388 *p*=0.012 | -0.686* | -0.582* | | - | | | - | | | - | |
| | CA | -0.452* | -0.476 *p*=0.003 | -0.751* | | | | | | | | | |
| P/Ca | IR | | | | | | | | - | | -0.999* | -0.998* | -0.999* |
| | E | | - | | | - | | | | | -0.999* | -0.996* | -0.997* |
| | CA | | | | | | | | | | -0.996* | -0.994* | -0.995* |

*p* – the statistical significance of differences; r -Pearson correlation coefficient; * (p<0.001); Group: I – teeth with a wedge-shaped defect and clinically intact hard tissues, II –teeth with cervical caries and clinically intact hard tissues, III –teeth with cervical pathology; Area: IR - incisal region (tubercle), E - equator, CA - cervical area

**Table 5.** Correlation between molar coefficients of enamel and dentin, r ($p$<0.0001)

| Molar coefficients | Area | Molar coefficients | | | | | |
|---|---|---|---|---|---|---|---|
| | | Mg/P | | | Ca/P | | |
| | | group | | | | | |
| | | I | II | III | I | II | III |
| P/Ca | IR | | - | | -0.9568 | -0.9646 | -0.9979 |
| | E | | | | -0.9773 | -0.9968 | -0.9782 |
| | CA | | | | -0.9316 | -0.9857 | -0.9219 |
| Mg/Ca | IR | 0.9945 | 0.9949 | 0.9965 | | - | |
| | E | 0.9974 | 0.9973 | 0.9964 | | | |
| | CA | 0.9844 | 0.9947 | 0.9879 | | | |

*p* – the statistical significance of differences; r -Pearson correlation coefficient; Group: I – teeth with a wedge-shaped defect and clinically intact hard tissues, II –teeth with cervical caries and clinically intact hard tissues, III –teeth with cervical pathology; Area: IR - incisal region (tubercle), E - equator, CA - cervical area

## Discussion

As a result of the study, the values of the molar coefficient of Ca/P were determined in the range of 1.79-2.07. According to other authors' data the coefficient of Ca/P ranged within 1.58[12] that may be due to the heterogeneity of the distribution of the chemical elements in dental hard tissues[13] and the associated difference in obtained results.[14] Compared with clinically intact teeth at the level of 5% smaller values of the coefficient of Ca/Mg in IR region and CA of dentin of the teeth with a wedge-shaped defect is probably due to tooth wear.[15] In all studied areas of the samples with cervical caries the molar coefficient of Ca/Mg was higher than in clinically intact ones that is explained by a higher concentration of magnesium in the hard tissues of healthy teeth according to the of data *Klimuszko E. et al.*[16] According to *Meisel P.et al.* (2016) the coefficient of Mg/Ca is serum that predicts periodontitis and tooth loss in a 5-year follow-up.[17]

Higher values of Na/Mg and lower values of Al/Zn were determined in all investigated areas of dentin of the samples with cervical caries. The tendency in the indicators of Na/Mg molar coefficient in the teeth with a carious process can be explained by the revealed significantly large amount of sodium in this group.[9] The lower values of Al/Zn coefficient in the samples with cervical caries are probably associated with a certain reliably high amount of zinc in all studied anatomical regions: from 3.8 times (at the E) to 23 times (in the IR) when comparing with dentin of the patients' teeth with a wedge-shaped defect and intact hard tissues, respectively.[9] *Shishniashvili T. et al.*[18] (2018) determined the increase in the content of zinc in the teeth with caries by 28.4% that they explained by its ability to reduce the permeability of enamel and, consequently, the transition of the chemical elements from saliva to hard dental tissues. *Zohoori FV.et al.*[19] (2020) found an inverse relationship between the incidence of tooth decay and aluminum levels in drinking water, food and soil. Other researchers confirmed the accumulation of aluminum and zinc in teeth dentin from the environment.[20] It was not possible to compare certain indicators of the molar coefficient of K/Na in dentin due to the lack of the information on its study in the available literary sources.

Correlation between the chemical composition of enamel and dentin (magnesium and calcium, magnesium and phosphorus) that was described in a previously published work[10] probably explains the revealed strong direct correlation between the molar coefficients of Mg/P and Mg/Ca in enamel and dentin. Obtained results confirm a certain role of Mg concentrations not only in the dental-enamel junction (according to *Kuczumow A. et al.* (2021))[21] but also in the entire thickness of hard tissues. In our opinion, the conducted research has confirmed the opinion of *Fernández-Escudero AC.et al.* (2020) that dentin presents physiological exchanges of in trace elements after a period of mineralization and some factors can influence its concentration[22], one of which is cervical pathology.

In our opinion, the limitation of the study is the insufficient number of the samples that is associated with the difficulties in obtaining them taking into account the patients' age. We believe that the further search for etiopathogenetic factors of the development of cervical pathology and the development of the methods for its prevention are promising.

## Conclusions

Revealed differences in the values of molar coefficients of chemical elements in dentin, depending on the topographical region and the state of the hard tissues of the teeth, their correlation with the indicators in enamel are probably associated with the peculiarities of the pathogenesis of a wedge-shaped defect and cervical caries and they are one of the risk factors for their occurrence which requires further study.

## Acknowledgements

None to declare

## Conflicts of Interest Statement

The author declares no conflict of interest in this study

## Funding

None to declare

## References


1. Peumans M, Politano G, Van Meerbeek B. Treatment of noncarious cervical lesions: when, why, and how. Int J Esthet Dent 2020;15(1):6-42.
2. Nascimento M, Dilbone D, Pereira P, Duarte W, Geraldeli S, Delgado A. Abfraction lesions: etiology, diagnosis, and treatment options. Clin Cosmet Investig Dent 2016;3(8):79-87.
3. Duruk G, Acar B, Temelli Ö. Effect of different doses of radiation on morphogical, mechanical and chemical properties of primary and permanent teeth-an in vitro study. BMC Oral Health 2020;20(1):242.
4. Tkachenko IM, Brailko NN, Kovalenko VV, Nazarenko ZJ, Sheshukova OV. Morphological study of enamel and dentin teeth with carious process and non-carous lesions. Wiadomosci Lekarskie 2018;71(5):1002-1005.
5. Longridge NN, Youngson CC. Dental pain: dentine sensitivity, hypersensitivity and cracked tooth syndrome. Prim Dent J 2019;20;8(1):44-51.
6. Tkachenko IM, Kovalenko VV. Research of microelement composition of enamel and dentine of teeth at caries and increased tooth erosion. Visnyk problem biolohii i medytsyny 2017;2(140),4:248-252.
7. Ranjitkar S, Turan A, Mann C, Gully GA, Marsman M, Edwards S, Kaidonis JA, Hall C, Lekkas D, Wetselaar P, Brook AH, Lobbezoo F, Townsend GC. Surface-sensitive microwear texture analysis of attrition and erosion. J Dent Res 2017;96(3):300-307.
8. Abou Neel EA, Aljabo A, Strange A, Ibrahim S, Coathup M, Young AM, Bozec L, Mudera V. Demineralization–remineralization dynamics in teeth and bone. Int J Nanomedicine 2016;11:4743–4763.
9. Yarova S, Zabolotna I, Genzytska O. Study of the morphological structure and chemical composition of the dentin of intact teeth and teeth with cervical pathology. Medical Studies/Studia Medyczne 2021;37(1):1–6.
10. Zabolotna I. Study of the morphological structure of enamel and correlation of its chemical composition with dentin in intact teeth and with a cervical pathology. J Stoma 2021;74(1):9-15.
11. Kurov IP, Skalnaya MG. Non-invasive study of indicators of mineral metabolism in young men with caries, chronic periodontitis and sanified mouth. Galician medical journal 2013;20(4):130-135.
12. Tytyuk SYu, Iordanishvili AK, Romanenko IG. Features of the morphological structure and chemical composition of hard tissues of teeth in Crohn's disease and chronic ulcerative colitis. Bulletin of the Medical Institute "REAVIZ" 2019;1:88-92.
13. de Souza-Guerra C, Barroso RC, de Almeida AP, Peixoto ITA, Moreira S, de Sousa FB, Gerlach RF. Anatomical variations in primary teeth microelements with known differences in lead content by micro-Synchrotron Radiation X-Ray Fluorescence (μ-SRXRF) – a preliminary study. J Trace Elem Med Biol 2014;28(2):186-193.
14. Srot V, Bussmann B, Salzberger U, Koch CT, van Aken PA. Linking microstructure and nanochemistry in human dental tissues. Microsc Microanal 2012;18(30):509-523.
15. Ey-Chmielewska H, Janiszewska-Olszowska J, Noceń I, Stępień P, Czajkowska A, Frączak B, Opalko K. Effect of pathological tooth wear on the content of calcium, magnesium, zinc and phosphate in human dentin. Magnes Res 2011;24(1):13-16.
16. Klimuszko E, Orywal K, Sierpinska T, Sidun J, Golebiewska M. Evaluation of calcium and magnesium contents in tooth enamel without any pathological changes: in vitro preliminary study. Odontology 2018;106(4):369-376.
17. Meisel P, Pink C, Nauck M, Jablonowski L, Voelzke H, Kocher T. Magnesium/calcium ratio in serum predicts periodontitis and tooth loss in a 5-year follow-up. JDR Clin Trans Res 2016; 1(3):266-274.
18. Shishniashvili T, Suladze N, Beridze M, Manjavidze N. Biosubstrates as dental health indicators in school-age children. Georgian Med News 2018;3(276):51-55.
19. Zohoori FV, Duckworth RM. Chapter 5: Microelements: Part II: F, Al, Mo and Co. Monogr Oral Sci 2020;28:48-58.
20. Asaduzzaman K, Khandaker MU, Binti Baharudin NA, Amin YBM, Farook MS, Bradley DA, Mahmoud O. Heavy metals in human teeth dentine: a bio-indicator of metals exposure and environmental pollution. Chemosphere 2017;176:221-230.
21. Kuczumow A, Chałas R, Nowak J, Lekki J, Sarna-Boś K, Smułek W, Jarzębski W. Novel approach to tooth chemistry. Quantification of the dental-enamel junction. Int J Mol Sci 2021;22(11):6003.
22. Fernández-Escudero AC, Legaz I, Prieto-Bonete G, López-Nicolás M, Maurandi-López A, Pérez-Cárceles MD. Aging and trace elements in human coronal tooth dentine. Sci Rep 2020;10(1):9964.

Cumhuriyet Dental Journal, 26(1): 8-16, 2023
DOI: https://doi.org/10.7126/cumudj.1118686

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 | Available online, ISSN: 1302-5805 e-ISSN: 2146-2852 | Publisher: Sivas Cumhuriyet Üniversitesi

# *Evaluation of the Application of Undergraduate Pre-Clinical Removable Prosthodontic Laboratory Teaching in General Dental Practice*

**Shivani Kohli[1-a*], Ashwin Kumar Sukumar[2-b], Shekhar Bhatia[1-c]**

[1] *MDS, MFDS RCPS (Glasgow), MFDS RCS (Edinburgh), Division of Restorative Dentistry, School of dentistry, International Medical University, Malaysia*
[2] *MDS, Department of Prosthodontics, MAHSA University, Selangor, Malaysia*
**Corresponding author*

**Research Article**

*History*

*Received: 21/05/2022*
*Accepted: 10/02/2023*



**ABSTRACT**

***Background:*** Pre-clinical removable prosthodontic training is an integral part of the undergraduate curriculum. The objectives of the study were to evaluate the application of pre-clinical removable prosthodontic laboratory training in general dental practice and the relevance of its teaching in the undergraduate curriculum.
***Methods:*** A descriptive questionnaire was developed to assess the extent of the practice of pre-clinical removable prosthodontic lab skills in their dental practice. The responses were evaluated and statistically analyzed with a significance value of $p<0.05$. Three hundred-fifty-seven general dental practitioners participated in the study.
***Results:*** 91% with 20 years of dental practice responded positively to the application of prosthodontic training in their practice. 55.7% with two years of training agreed to dedicate more time to clinical prosthodontics training.
***Conclusions:*** 52.9% of the participants agreed that it would be better to dedicate more time to clinical prosthodontics training rather than pre-clinical removable prosthodontics lab training as a part of the undergraduate prosthodontic curriculum, among which more than 60% of the study participants had two or more years of removable prosthodontics pre-clinical training during dental school.
***Practical implications:*** Clinical expertise of dental graduates is an essential component in the general dental practice. Hence, there is a need to revisit removable prosthodontic curriculum content and time distribution in the undergraduate dental program.

***Key words:*** Undergraduate, Simulation, Pre-Clinical, Laboratory, Training, General Dental Practice.

[a] drshivanidentist@gmail.com https://orcid.org/0000-0002-4697-4236
[b] ash.bds@gmail.com https://orcid.org/0000-0003-0630-3865
[c] ShekharBhatia@imu.edu.my https://orcid.org/0000-0003-3330-5823

*How to Cite: Kohli S, Kumar Sukumar A, Bhaita S. (2023) Evaluation of the Application of Undergraduate Pre-Clinical Removable Prosthodontic Laboratory Teaching in General Dental Practice, Cumhuriyet Dental Journal, 26(1):8-16.*

## Introduction

The motive of the dental curriculum is to upgrade and enhance clinical abilities with consistent expert improvement, basic thinking, and research. Thus, educational modules should be intended to give learning conditions that can be quantified and calibrated. These modules are required to be adjusted according to the current research and its application in dental practice.[1]

Presently in Malaysia, there is no single standard curriculum for all dental schools. The Ministry of Higher Education and the Ministry of Health have been working together to promote scientifically based dental education. The Malaysian dental curriculum consists of two years of mainly preclinical didactic and laboratory training, and three years of mainly clinical training, which is supervised by different faculty members. The third year of the dental program includes lectures and ward-round rotations in a medical hospital as well as an introduction to clinical dentistry. In the fourth year, students undertake didactic clinical and laboratory coursework, and in the fifth-year dental students are mainly involved in patient care in dental clinics.[2]

Malaysian Dental curriculum content is generally like that of the United Kingdom. Further, many of the lecturers and dental specialists in Malaysia are trained in the UK and Ireland.[3] According to National Oral Health Plan for Malaysia, there is a need to manage and track edentulism among young adults 35-44 years of age and the elderly of 60+ years. Edentulism has declined among Malaysian adults, however, in 2000, 2.8% of the 35-44 age group and 32.1% of the 60-70 age group were still reported as edentulous.[4] The National Oral Health Survey of Adults reported 50.8% of elderly aged 60 years and older had some form of oral prostheses and a majority (31.8%) were females (Oral Health Division, 2004).[5] Hence there is a need to tailor the removable prosthodontic curriculum to satisfy the needs of the current population.

The dental curriculum for under-graduates in most dental schools includes pre-clinical training in the initial years followed by clinical training. Pre-clinical removable prosthodontic training ranges from 6 months to 2 years' time frame although the curriculum requirements of all dental schools in Malaysia are the same. The pre-clinical training is

comprised mainly of laboratory procedures needed for the fabrication of both complete and partial removable dentures. This training includes the preparation of models, fabrication of custom trays, record bases, occlusal rims, mounting on articulators, teeth arrangement, and processing of dentures. All these exercises are preceded by a lecture and demonstration following which the students are required to complete these individual exercises.[6,7]

Around the world, there have been reports emphasizing the need for dental educators to reconsider the predoctoral prosthodontics curriculum to make it greatly applicable to scientific practice for the overall practitioner.[8,9] Such a curriculum may be important considering that millions of people without complete dentitions will probably require prosthodontic treatment in the 21st century.[9-13] Techniques that are taught in dental schools are frequently not used in general dental practice.[14] According to the previous surveys, there are differences between what is taught as accepted prosthodontic practices and what is practiced.[15-19]

In some dental schools, students are expected to perform all the laboratory procedures. Hence there is no doubt that these students have a sound knowledge regarding the technical aspect of the prosthodontic course. But this opinion has varied as in some schools the need for such extensive training was considered questionable as the patient's laboratory work was done by the technician and the students graduated with a desirable understanding of the lab procedures.[20,21]

Extensive laboratory hours in some dental schools have compromised the desirable clinical teaching hours hence the training achieved by the graduates in removable prosthodontics is the weakest among the other subject of the undergraduate training program.[22] However, studies exploring and evaluating the usefulness, particularly of preclinical removable prosthodontic learning in general dental practice are scarce.[23,24]

Along these lines, dental training programs should ceaselessly assess their part of the removable prosthodontic educational modules to guarantee that the dental needs of society and the objectives and targets of the population are being met.[25,26] This implies learning and aptitudes in treating patients with edentulism will be essential as the century advances.[26] Prosthodontic educational modules and lab delegation reviews are valuable devices for evaluating prosthodontic education.[25] Hence, the study aimed to evaluate the usefulness of pre-clinical removable prosthodontic laboratory training in dental practice among general dental practitioners in Malaysia and to evaluate the relevance of teaching pre-clinical prosthodontics in the undergraduate curriculum which was done with the help of responses achieved to the developed questionnaire.

## Material and Methods

A descriptive questionnaire was developed, aiming to assess the extent of the practice pre-clinical removable prosthodontic lab skills in their dental practice. The questionnaire was developed keeping in mind, the common procedures that general dental practitioners encounter in their practice. Hence, this cross-sectional face-to-face survey was conducted among government and private general dental practitioners who attended dental conferences in Malaysia in the year 2017. The questionnaire was validated and pre-tested on the dental officers at the MAHSA University, Malaysia before they were distributed to the participants.

Ethical approval was taken by the Research Management Centre of MAHSA University (RMC/EC10/2015). According to a survey conducted by the Ministry of Health, Malaysia (2013) the dentist-to-population ratio was 1:6346 with the total number of dentists being 4558. The convenience sampling method was used to achieve the sample size of 357 with a confidence level of 95% and a confidence interval of 5. The survey form was prepared in English with closed-ended responses. The purpose of the research and the risks involved were explained to the participants before the commencement of the study. All the participants gave informed consent before answering the questionnaire. Responses were obtained in person from all the participants.

The questionnaire consisted of two parts: In Part 1, the demographic details including age, gender, and years of practice were recorded. Along with this, participants were questioned on the duration of pre-clinical removable prosthodontic lab training during their undergraduate curriculum and do they perform removable prosthodontic procedures in their general practice. If so, are they able to apply the knowledge gained by preclinical training to their general practice? The participants who did not practice removable prosthodontic procedures in their clinic were eliminated from the study.

In part 2 of the questionnaire, a total of nine questions were included based on the commonly taught procedures in undergraduate pre-clinical removable prosthodontics like manipulation of impression material, pouring of impressions, construction of custom trays, record bases, occlusal rims, teeth arrangement and processing of dentures in their clinical practice. Further questions on designing the partial denture, tracking back the technician's work, and willingness to correct the mistakes in the technician's work by themselves were also included. Likert's three-point scale of "always, sometimes, never" was used to record the responses.

The final question was to ask the level of agreement towards the statement "It would be better to dedicate more time to clinical prosthodontic training rather than pre-clinical prosthodontic lab training in the undergraduate curriculum." The response to this last question was recorded using Likert's five-point scale for degree of agreement. Responses were evaluated and data were tabulated and statistically analyzed using the Chi-Square test with a significance value of $p<0.05$.

## Results

A total of 357 general dental practitioners participated in the study, out of which 113 were males and 244 were

females. The demographic variables and the response of the participant to pre-clinical removable prosthodontics training based on the years of practice, and period of pre-clinical removable prosthodontic training in their undergraduate curriculum are shown in Table 1. Of all, 94.1% responded positively regarding the application of pre-clinical prosthodontic training in their daily clinical practice. Interestingly, 4.2% (15) of the subjects did not perform removable prosthodontics in their practice at all. The responses of these subjects were eliminated from the statistical analysis. Table 2 and 3 depicts the association between years of practice and duration of training to the application of preclinical removable prosthodontic lab training in their dental practice.

Table 2 depicts a non-significant association between years of dental practice to the application of preclinical removable prosthodontic lab training stating the response range between 91% to 100% irrespective of their years of practice which ranged between less than years and more than 20 years. Table 3 shows that 98.1% of the participants with pre-clinical training longer than 2 years, were able to apply their training knowledge to dental practice.

The next section of the questionnaire was designed to gather information regarding different preclinical procedures performed by dental practitioners during their daily practice as seen in (Table 4). 50.3% of participants manipulated impression materials on their own, 19.3% always poured their patient's impressions, 57.9% of the dentist never fabricated custom trays, 40.6% of the participants never fabricated record base and occlusal rim on their own, only 12% of clinicians always did teeth arrangement by themselves and processing of dentures was never performed by 78.9% of the clinicians. Almost 70% of the participants always designed their patient's partial denture, 41.8% of subjects always corrected it on their own, majority of the subjects always tracked the dental technician's work to their satisfaction. A graphic representation of the participant's response to questions on different preclinical laboratory procedures is presented in Figure 1.

Almost half of the subjects, 52.9% either agreed or strongly agreed with the statement "It would be better to dedicate more time to clinical prosthodontic training rather than pre-clinical removable prosthodontic laboratory training in the undergraduate curriculum." (Table 5) while more than 60% of the study participants had two or more years of Prosthodontics pre-clinical training during dental school. Comparing years of preclinical training to response, a statistically significant association (p-value = 0.03) was seen when questioned about the processing of dentures on their own, 86.7% of the participants with two years of preclinical training never performed this procedure on their own. Half of the participants with pre-clinical training of six months and more than two years if not satisfied with the dental technician's work always do the corrections by themselves (p-value = 0.03) and 54.7% of them never performed teeth arrangement with a p-value of 0.02 (Table 6). Regarding the fabrication of record bases and occlusal rims, a statistically significant association (p-value 0.03) was observed between the years of experience of the participants and the response with only 25.3% of the participants with more than twenty years of experience prepared record bases and occlusal rims on their own and 38.7% of them with the same experience never perform this procedure. More than 50% of the participants with experience of more than twenty years strongly agreed/agreed that it would be better to dedicate more time to clinical prosthodontics training rather than pre-clinical prosthodontic lab training in the undergraduate curriculum with a P value of 0.02 (Table 7).

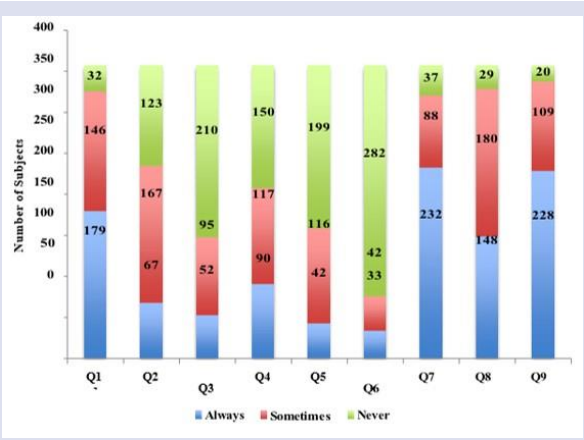



Figure 1. Graphic representation of the participant's response to questions on different preclinical procedures. Kindly refer to Table 2 to read the question statements.

## Discussion

The undergraduate dental curriculum is undergoing rapid change and revision in dental schools worldwide. Although the current undergraduate removable prosthodontic curriculum has seen very little change in the past years.[12,27]

As seen in the present study, irrespective of being trained from different dental schools all participants did receive pre-clinical prosthodontics training as a part of their curriculum through the duration of training varied. The reason could be the difference in the number of exercises taught; expected practical assessments and could even be the planned time dedicated to the clinic to satisfy their clinical requirement which may also generally vary from one university to the other. These findings are in accordance with Weider et al who conducted a study among 13 UK dental schools enquiring about the number of hours spent in the laboratory and dental clinic. The results revealed great disparity among them, four schools devoted more time to the laboratory work whereas three dental schools devote more time to the clinic and one school also reported no dedicated clinical time for complete dentures with variation in the quota of complete dentures to be issued to the patient during the program.[28]

Regarding prosthodontic techniques teaching some skills such as pouring casts and making custom trays and wax rims may be beneficial to learn. It is critically imperative that students learn to differentiate between work that is up to standard and fulfills the requirements of the case and that which does not[20] as in the present

study only 47.7% of the practitioners sometimes pour the impressions and 57.9% of them never make custom trays and 40.6% of them never made occlusal rims on their own.

A study was conducted by Rashedi B in 2001 wherein a questionnaire was mailed to the chairpersons of the prosthodontic/restorative departments of 54 U.S. dental schools requesting information on their predoctoral preclinical complete denture curricular content to which 43 schools responded. The overall mean number of months that the complete denture preclinical course is offered was five months whereas in the present study only 9% of the participants had preclinical training of six months which could be inclusive of both complete and partial denture laboratory procedure and 33.3% of participants had training period of two years and 29.7% had training of more than two years. He also reported one school (2%) having no laboratory component, with all teaching occurring in the clinic which is in total contrast with the results achieved in the present study. Twenty-seven schools (63%) reported that students do not process their complete denture setups made during the course and seven schools (16%) indicated processing was done sometimes. The schools that indicated "sometimes'' commented: "if they choose to,'' "first case only,'' "very rarely,'' "if rushed,'' "juniors yes and seniors no,'' and "relines occasionally.'' This was in accordance with the present study wherein 78.9% of dental practitioners don't process their dentures and only 11.4% sometimes process them irrespective of being trained during preclinical years.[12]

The results of the present study reveal most dental practitioners do not perform laboratory procedures such as the fabrication of special trays, record bases, occlusal rims, artificial teeth arrangement, and processing of the dentures on their own. Hence, the preparation of one of these kinds or a demonstration of these steps during the preclinical year could be just enough for the dental student to judge the quality of work produced by the dental technicians. Another reason could be the availability of all the laboratory instruments and equipment in their clinical setup and the time needed for executing these lab procedures, which a dentist would prefer to give in their clinical practice.

As observed in the present study, 54.7% (187) participants did not perform teeth arrangement irrespective of their training, which could be due to the easy availability of trained dental technicians. Singh et al reported 88.6% of the practitioners get their lab work done by technicians and use their expertise to evaluate whether the work done by technicians is acceptable or not.[29]

For many years, fundamental problems have been observed among dental professionals when prescribing, designing, and fabricating removable partial dentures.[30-36] Sykora has doomed the practice of lab technicians designing the removable partial denture frameworks as they cannot make correct decisions without biological knowledge of the oral structures. This is in line with the findings of the present study as only 9.9% of the practitioners' used lab technicians for designing their framework.[37]

The current trend appears toward more work being delegated to the laboratory technician, with student involvement not needed in every laboratory step.[38,39] Weider et al investigated the opinions of a cohort of dental practitioners in the UK regarding their skill and competence in their educational background in complete denture and revealed the average number of dentures made was only three and 37% felt that their training has given them experience and confidence in complete dentures.[40]

General dental practitioners' perceptions of removable – prosthodontics in the undergraduate curriculum in New Zealand supported modifications in the existing removable prosthodontics curriculum to suit the modern general dental practice and to focus more on the clinics by reducing students' exposure time to the laboratory.[41] Similarly in the present study, more than 50 % of the practitioners also agreed to dedicate more time to clinics rather than a lab. This could be due to their clinical perception they foresee that the dentist who graduated are not confident to accept edentulous patients, which was also stated by Clark.[20]

## Conclusions

52.9% of the participants agreed that it would be better to dedicate more time to clinical prosthodontics training rather than pre-clinical removable prosthodontics lab training as a part of the undergraduate prosthodontic curriculum, among which more than 60% of the study participants had two or more years of removable prosthodontics pre-clinical training during dental school. As observed in this study, the dental clinician does not perform certain procedures on their own for example, 78.9% of the dental practitioners in the present study never acrylized their patient's dentures and around 50% of the participant never fabricated special trays, record bases, and occlusal rims or performed artificial teeth arrangement irrespective of being trained during preclinical years. Hence, this necessitates an open discussion on removable prosthodontic curriculum content and its allocated time within the undergraduate dental program.

### Author Contributions

Conceptualization, S.K and A.K.S.; methodology, S.K and A.K.S.; investigation, S.K.; resources, S.K and A.K.S.; data curation, S.K.; writing–original draft preparation, S.K and S.B.; writing–review and editing, S.K and S.B.; project administration, S.K and A.K.S. All authors have read and agreed to the published version of the manuscript.

### Funding

The present research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

### Institutional Review Board Statement

The protocol was reviewed by the Ethics Committee and approved by the Research Management Centre of MAHSA University.

### Informed Consent Statement

Informed consent was obtained from all subjects involved in the study. Participation in the study was voluntary. The study was performed in accordance with the principles of the Helsinki Declaration regarding anonymity and integrity.

### Data Availability Statement

The data presented in this study are available on request from the corresponding author.


### Acknowledgments

We would like to express our thanks to all the dentists who participated in this study. Their participation made this study possible. We also would like to express our gratitude to Dr. Vinayak for his statistical advice during the preparation of this paper.


### Conflicts of Interest

The authors declare no conflict of interest.

**Table 1.** Demographic variables and the response of the participant to pre-clinical removable prosthodontics training

| Demographic variables of the participants (n=357) | | | |
|---|---|---|---|
| | | Frequency (n) | Percentage (%) |
| Gender | Male | 113 | 31.7 |
| | Female | 244 | 68.3 |
| Number of years of dental practice | < 5 years | 164 | 45.9 |
| | 5 – 9 years | 60 | 16.8 |
| | 10 – 14 years | 30 | 8.4 |
| | 15 -19 years | 25 | 7.0 |
| | >20 years | 78 | 21.8 |
| **Participants' response to pre-clinical removable prosthodontics training** | | | |
| What was the time allocated for pre-clinical removable prosthodontic lab training in your university? | 6 months | 32 | 9.0 |
| | 1 year | 100 | 28.0 |
| | 2 years | 119 | 33.3 |
| | >2years | 106 | 29.7 |
| Are you able to apply pre-clinical removable prosthodontic training in your daily clinical practice? | Yes | 336 | 94.1 |
| | No | 21 | 5.9 |
| Do you perform removable prosthodontics procedures in your clinic? | Yes | 342 | 95.8 |
| | No | 15 | 4.2 |

**Table 2.** Association between years of practice and application of preclinical removable prosthodontic lab training in their dental practice

| Years of practice | Are you able to apply training in your practice | | Total | Fisher's Exact Test |
|---|---|---|---|---|
| | No | Yes | | p-value |
| **< 5 years** | 12 | 152 | 164 | 0.054(NS) |
| | 7.3% | 92.7% | 100.0% | |
| **5 – 9 years** | 0 | 60 | 60 | |
| | 0.0% | 100.0% | 100.0% | |
| **10 – 14 years** | 0 | 30 | 30 | |
| | 0.0% | 100.0% | 100.0% | |
| **15 – 19 years** | 2 | 23 | 25 | |
| | 8.0% | 92.0% | 100.0% | |
| **>20 years** | 7 | 71 | 78 | |
| | 9.0% | 91.0% | 100.0% | |
| **Total** | 21 | 336 | 357 | |
| | 5.9% | 94.1% | 100.0% | |

**p<0.05 Statistically Significant, p>0.05 Non-Significant, NS*

**Table 3.** Association between duration of training and application of preclinical removable prosthodontic lab training in their dental practice

| Duration of training | Are you able to apply training in your practice? | | Total | Chi-Square Test | |
|---|---|---|---|---|---|
| | No | Yes | | Chi-Square Value | P-Value |
| **6 months** | 6 | 26 | 32 | 13.87 | 0.003* |
| | 18.8% | 81.3% | 100.0% | | |
| **1 year** | 4 | 96 | 100 | | |
| | 4.0% | 96.0% | 100.0% | | |
| **2 years** | 9 | 110 | 119 | | |
| | 7.6% | 92.4% | 100.0% | | |
| **>2 years** | 2 | 104 | 106 | | |
| | 1.9% | 98.1% | 100.0% | | |
| **Total** | 21 | 336 | 357 | | |
| | 5.9% | 94.1% | 100.0% | | |

**p<0.05 Statistically Significant, p>0.05 Non-Significant, NS*

**Table 4.** Participants' response to different preclinical procedures, if they perform removable prosthodontics procedures in their daily practice (n=342)

| | Always | Sometimes | Never |
|---|---|---|---|
| 1. Manipulation of the impression material is done by me | 172 (50.3) | 142 (41.5) | 28 (8.2) |
| 2. Pouring of the impressions is done by me | 66 (19.3) | 163 (47.7) | 113 (33.0) |
| 3. Construction of the custom trays is done by me | 52 (15.2) | 92 (26.9) | 198 (57.9) |
| 4. Fabrication of the record bases and occlusal rims is done by me | 89 (26.0) | 114 (33.3) | 139 (40.6) |
| 5. Artificial teeth arrangement for denture patients is done by me | 41 (12.0) | 114 (33.3) | 187 (54.7) |
| 6. Processing (acrylization) of dentures is done by me | 33 (9.6) | 39 (11.4) | 270(78.9) |
| 7. Designing of the partial denture framework is done by me | 224 (65.5) | 84 (24.6) | 34 (9.9) |
| 8. If you are not satisfied with your dental technician's work, you correct it by yourself | 143(41.8) | 171(50.0) | 28(8.2) |
| 9. Do you track your dental technician's work to your satisfaction? | 222(64.9) | 101(29.5) | 19(5.6) |

**p<0.05 Statistically Significant, p>0.05 Non-Significant, NS*

**Table 5.** Participants' responses to the statement- "It would be better to dedicate more time on clinical prosthodontic training rather than pre-clinical prosthodontic laboratory training in undergraduate

| | | Frequency (%) |
|---|---|---|
| 10. To what extent do you agree or disagree with this statement: "It would be better to dedicate more time on clinical prosthodontic training rather than pre-clinical removable prosthodontic laboratory training in undergraduate curriculum". | Strongly agree | 49 (13.7) |
| | Agree | 140 (39.2) |
| | Neutral | 82(23.0) |
| | Disagree | 67(18.8) |
| | Strongly disagree | 19(5.3) |

**Table 6.** Comparison of years of preclinical removable prosthodontic lab training to responses, among clinicians who perform removable prosthodontics procedure in their daily practice

| | | Time allocated to preclinical removable prosthodontic lab training in your university | | | | Total | Chi-square test | |
|---|---|---|---|---|---|---|---|---|
| | | 6 months | 1 year | 2 years | >2 years | | Chi-square value | p-value |
| Q1 | Always | 13(43.3%) | 47 (48.5%) | 56 (49.6%) | 56(54.9%) | 172(50.3%) | 4.17 | 0.61 (NS) |
| | Sometimes | 13 (43.3%) | 41(42.3%) | 51(45.1%) | 37(36.3%) | 142(41.5%) | | |
| | Never | 4(13.3%) | 9(9.3%) | 6(5.3%) | 9(8.8%) | 28(8.2%) | | |
| Q2 | Always | 6(20.0%) | 20(20.6%) | 22(19.5%) | 18(17.6%) | 66(19.3%) | 1.31 | 0.97 (NS) |
| | Sometimes | 13(43.3%) | 48(49.5%) | 51(45.1%) | 51(50.0%) | 163(47.7%) | | |
| | Never | 11(36.7%) | 29(29.9%) | 40(35.4%) | 33(32.4%) | 113(33.0%) | | |
| Q3 | Always | 3(10.0%) | 19(19.6%) | 13(11.5%) | 17(16.7%) | 52(15.2%) | 6.99 | 0.32 (NS) |
| | Sometimes | 12(40.0%) | 27(27.8%) | 27(23.9%) | 26(25.5%) | 92(26.9%) | | |
| | Never | 15(50.0%) | 51(52.6%) | 73(64.6%) | 59(57.8%) | 198(57.9%) | | |
| Q4 | Always | 7(23.3%) | 29(29.9%) | 24(21.2%) | 29(28.4%) | 89(26.0%) | 10.81 | 0.09 (NS) |
| | Sometimes | 11(36.7%) | 38(39.2%) | 30(26.5%) | 35(34.3%) | 114(33.3%) | | |
| | Never | 12(40.0%) | 30(30.9%) | 59(52.2%) | 38(37.3%) | 139(40.6%) | | |
| Q5 | Always | 2(6.7%) | 17(17.5%) | 11(9.7%) | 11(10.8%) | 41(12.0%) | 14.84 | 0.02* |
| | Sometimes | 11(36.7%) | 37(38.1%) | 26(23.0%) | 40(39.2%) | 114(33.3%) | | |
| | Never | 17(56.7%) | 43(44.3%) | 76(67.3%) | 51(50.0%) | 187(54.7%) | | |
| Q6 | Always | 1(3.3%) | 14(14.4%) | 9(8.0%) | 9(8.8%) | 33(9.6%) | 14.24 | 0.03* |
| | Sometimes | 3(10.0%) | 11(11.3%) | 6(5.3%) | 19(18.6%) | 39(11.4%) | | |
| | Never | 26(86.7%) | 72(74.2%) | 98(86.7%) | 74(72.5%) | 270(78.9%) | | |
| Q7 | Always | 19(63.3%) | 61(62.9%) | 72(63.7%) | 72(70.6%) | 224(65.5%) | 9.88 | 0.13 (NS) |
| | Sometimes | 10(33.3%) | 28(28.9%) | 23(20.4%) | 23(22.5%) | 84(24.6%) | | |
| | Never | 1(3.3%) | 8(8.2%) | 18(15.9%) | 7(6.9%) | 34(9.9%) | | |
| Q8 | Always | 15(50.0%) | 40(41.2%) | 37(32.7%) | 51(50.0%) | 143(41.8%) | 13.91 | 0.03* |
| | Sometimes | 12(40.0%) | 49(50.5%) | 61(54.0%) | 49(48.0%) | 171(50.0%) | | |
| | Never | 3(10.0%) | 8(8.2%) | 15(13.3%) | 2(2.0%) | 28(8.2%) | | |
| Q9 | Always | 18(60.0%) | 61(62.9%) | 69(61.1%) | 74(72.5%) | 222(64.9%) | 6.69 | 0.35 (NS) |
| | Sometimes | 11(36.7%) | 31(32.0%) | 34(30.1%) | 25(24.5%) | 101(29.5%) | | |
| | Never | 1(3.3%) | 5(5.2%) | 10(8.8%) | 3(2.9%) | 19(5.6%) | | |
| Q10 | Strongly agree | 1(3.3%) | 12(12.4%) | 19(16.8%) | 14(13.7%) | 46(13.5%) | 9.42 | 0.67 (NS) |
| | Agree | 15(50.0%) | 35(36.1%) | 44(38.9%) | 38(37.3%) | 132(38.6%) | | |
| | Neutral | 9(30.0%) | 26(26.8%) | 22(19.5%) | 22(21.6%) | 79(23.1%) | | |
| | Disagree | 4(13.3%) | 18(18.6%) | 24(21.2%) | 20(19.6%) | 66(19.3%) | | |
| | Strongly disagree | 1(3.3%) | 6(6.2%) | 4(3.5%) | 8(7.8%) | 19(5.6%) | | |

**Table 7.** Comparison of years of experience and responses, among clinicians who perform removable prosthodontics procedures in their daily practice

| | | Years of practice | | | | | Total | Chi-square test | |
|---|---|---|---|---|---|---|---|---|---|
| | | <5 years | 5-9 years | 10-14 years | 15-19 years | >20 years | | Chi-square value | p-value |
| Q1 | Always | 75(47.5%) | 29(50.0%) | 10(37.0%) | 14(58.3%) | 44 (58.7%) | 172(50.3%) | 8.46 | 0.39 (NS) |
| | Sometimes | 68(43.0%) | 26(44.8%) | 14(51.9%) | 10(41.7%) | 24 (32.0%) | 142 (41.5%) | | |
| | Never | 15(9.5%) | 3(5.2%) | 3(11.1%) | 0(0.0%) | 7(9.3%) | 28(8.2%) | | |
| Q2 | Always | 32(20.3%) | 7(12.1%) | 3(11.1%) | 4(16.7%) | 20(26.7%) | 66(19.3%) | 11.98 | 0.15 (NS) |
| | Sometimes | 77(48.7%) | 33(56.9%) | 9(33.3%) | 12(50.0%) | 32(42.7%) | 163(47.7%) | | |
| | Never | 49(31.0%) | 18(31.0%) | 15(55.6%) | 8(33.3%) | 23(30.7%) | 113(33.0%) | | |
| Q3 | Always | 22(13.9%) | 11(19.0%) | 3(11.1%) | 5(20.8%) | 11(14.7%) | 52(15.2%) | 3.30 | 0.91 (NS) |
| | Sometimes | 40(25.3%) | 15(25.9%) | 7(25.9%) | 8(33.3%) | 22(29.3%) | 92(26.9%) | | |
| | Never | 96(60.8%) | 32(55.2%) | 17(63.0%) | 11(45.8%) | 42(56.0%) | 198(57.9%) | | |
| Q4 | Always | 36(22.8%) | 24(41.4%) | 6(22.2%) | 4(16.7%) | 19(25.3%) | 89(26.0%) | 16.23 | 0.03* |
| | Sometimes | 47(29.7%) | 20(34.5%) | 8(29.6%) | 12(50.0%) | 27(36.0%) | 114(33.3%) | | |
| | Never | 75(47.5%) | 14(24.1%) | 13(48.1%) | 8(33.3%) | 29(38.7%) | 139(40.6%) | | |
| Q5 | Always | 24(15.2%) | 8(13.8%) | 1(3.7%) | 3(12.5%) | 5(6.7%) | 41(12.0%) | 6.68 | 0.57 (NS) |
| | Sometimes | 50(31.6%) | 17(29.3%) | 10(37.0%) | 10(41.7%) | 27(36.0%) | 114(33.3%) | | |
| | Never | 84(53.2%) | 33(56.9%) | 16(59.3%) | 11(45.8%) | 43(57.3%) | 187(54.7%) | | |
| Q6 | Always | 19(12.0%) | 5(8.6%) | 1(3.7%) | 3(12.5%) | 5(6.7%) | 33(9.6%) | | 0.71 (NS)# |
| | Sometimes | 22(13.9%) | 6(10.3%) | 3(11.1%) | 1(4.2%) | 7(9.3%) | 39(11.4%) | | |
| | Never | 117(74.1%) | 47(81.0%) | 23(85.2%) | 20(83.3%) | 63(84.0%) | 270(78.9%) | | |
| Q7 | Always | 108(68.4%) | 42(72.4%) | 19(70.4%) | 16(66.7%) | 39(52.0%) | 224(65.5%) | 9.34 | 0.32 (NS) |
| | Sometimes | 35(22.2%) | 11(19.0%) | 6(22.2%) | 7(29.2%) | 25(33.3%) | 84(24.6%) | | |
| | Never | 15(9.5%) | 5(8.6%) | 2(7.4%) | 1(4.2%) | 11(14.7%) | 34(9.9%) | | |
| Q8 | Always | 70(44.3%) | 17(29.3%) | 9(33.3%) | 8(33.3%) | 39(52.0%) | 143(41.8%) | 13.83 | 0.09 (NS) |
| | Sometimes | 73(46.2%) | 39(67.2%) | 16(59.3%) | 14(58.3%) | 29(38.7%) | 171(50.0%) | | |
| | Never | 15(9.5%) | 2(3.4%) | 2(7.4%) | 2(8.3%) | 7(9.3%) | 28(8.2%) | | |
| Q9 | Always | 100(63.3%) | 35(60.3%) | 19(70.4%) | 14(58.3%) | 54(72.0%) | 222(64.9%) | | 0.61 (NS) |
| | Sometimes | 49(31.0%) | 20(34.5%) | 6(22.2%) | 7(29.2%) | 19(25.3%) | 101(29.5%) | | |
| | Never | 9(5.7%) | 3(5.2%) | 2(7.4%) | 3(12.5%) | 2(2.7%) | 19(5.6%) | | |
| Q10 | Strongly agree | 20(12.7%) | 10(17.2%) | 1(3.7%) | 5(20.8%) | 10(13.3%) | 46(13.5%) | 19(5.6%) | 0.02* |
| | Agree | 71(44.9%) | 19(32.8%) | 12(44.4%) | 6(25.0%) | 24(32.0%) | 132(38.6%) | | |
| | Neutral | 42(26.6%) | 11(19.0%) | 9(33.3%) | 6(25.0%) | 11(14.7%) | 79(23.1%) | | |
| | Disagree | 19(12.0%) | 13(22.4%) | 3(11.1%) | 5(20.8%) | 26(34.7%) | 66(19.3%) | | |
| | Strongly disagree | 6(3.8%) | 5(8.6%) | 2(7.4%) | 2(8.3%) | 4(5.3%) | | | |

*#Fishers exact test*

**p<0.05 Statistically significant, p>0.05 Nonsignificant*

## References


1. Ditmyer MM, Mobley CC, Davenport WD. Evaluation of an integrative model for professional development and research in a dental curriculum. J Dent Educ 2014;78(3):368-379.
2. Komabayashi T, Razak AA, Bird WF. Dental education in Malaysia. Int Dent J 2007; 57(6):429-432.
3. Ngeow WC. Dental fellowship training in Malaysia- A personal experience. J Irish Dent Assoc 1997;43:82-84.
4. Oral Health Division, Ministry of Health Malaysia. National Oral Health Plan for Malaysia 2011-2020. February 2011. Serial No. MOH/K/GIG/ 7.2011(BK).
5. Oral Health Division, Ministry of Health Malaysia. National Oral Health Survey of Adults 2000 (NOHSA 2000). Oral health status, impacts and treatment needs of Malaysian adults, Nov 2004.
6. Morrow RM, Rudd KD, Rhodes JE. Complete Dentures, 2nd edition. St. Luois: The CV Mosby Company; 1986.
7. Rudd KD, Morrow RM, Eissmann HF. Dental Laboratory Procedures - Removable Partial Dentures, Vol. III 2nd Edition. St. Louis, Missouri: CV Mosby; 1986.
8. Institute of Medicine (US) Committee on the Future of Dental Education. Dental Education at the Crossroads: Challenges and Change. Field MJ, editor. Washington (DC): National Academies Press (US); 1995.
9. Meskin LH, Brown LJ. Prevalence and patterns of tooth loss in US employed adult and senior populations 1985-86. J Dent Educ 1988;52(12):686-691.
10. Taylor TD, Aquilino SA, Matthews AC, et al: Prosthodontic survey. Part II: Removable prosthodontic curriculum survey. J Prosthet Dent 1984;52(5):747-749.
11. Budtz-Jorgensen E: Treatment of Edentulous Patients, in Prosthodontics for the Elderly: Diagnosis and Treatment. Chicago, IL, Quintessence, 1999, pp. 203-228.
12. Rashedi B, Petropoulos VC. Preclinical complete dentures curriculum survey. J Prosthodont 2003;12(1):37-46.
13. Douglass CW1, Shih A, Ostry L. Will there be a need for complete dentures in the United States in 2020? J Prosthet Dent. 2002;87(1):5-8.
14. Graser GN. Predoctoral removable prosthodontics education. J Prosthet Dent. 1990;64(3):326-333.

**15.** Hyde PT, McCord JF. Survey of prosthodontic impression procedures for complete dentures in general dental practice in the United Kingdom. J Prosthet Dent. 1999;81(3):295-259.

**16.** Jaggers JH, Javid NS, Colaizzi FA. Complete denture curriculum survey of dental schools in the United States. J Prosthet Dent.1985;53(5):736-739.

**17.** Mendes AJ. Application of prosthodontic techniques in private practice. J Prosthet Dent. 1985;54(5):730-735.

**18.** Murphy WM, Bates JF, Huggett R. Complete denture construction in general dental practice: A Survey. Br Dent J 1971;130(12):514-521.

**19.** Murphy WM, Bates JF Stafford GD. Complete denture construction in dental schools and hospitals of the United Kingdom and Ireland. A survey. Br Dent J 1972;133(5):179-184.

**20.** Clark RKF. The future of teaching of complete denture construction to undergraduates, Br Dent J 2002;193(1):13-14.

**21.** Clark RKF, Radford DR, Juszczyk AS. Current trends in complete denture teaching in British dental schools. Br Dent J. 2010;208(5):214-215.

**22.** Cabot L B. The dental vocational training experience: a transition from novice dentist to competent practitioner. pp 84. UK: Open University, 2004. D.Ed. Thesis.

**23.** Dantas AK, Shinagawa A, Deboni MCZ. Assessment of preclinical learning on oral surgery using three instructional strategies. J Dent Educ. 2010;74(11):1230-1236.

**24.** Grober ED, Hamstra SJ, Wanzel KR, et al. The educational impact of bench model fidelity on the acquisition of technical skill: the use of clinically relevant outcome measures. Ann Surg 2004; 240(2):374–381.

**25.** Goodacre CJ: Predoctoral fixed prosthodontics education. J Prosthet Dent 1990;64(3):319-325.

**26.** Lang BR: A review of traditional therapies in complete dentures. J Prosthet Dent 1994;72(5):538-542.

**27.** Petropoulos VC, Rashedi B. Complete denture education in U.S. dental schools. J Prosthodont. 2005;14(3):191-197.

**28.** Wieder M, Faigenblum M, Eder A, Louca C. An investigation of complete denture teaching in the UK: Part 1. A survey of undergraduate teaching. Br Dent J 2013; 215(4):177-181.

**29.** Singh G, Kapoor V, Gambhir R, Bansal V. Application of prosthodontic techniques by private practitioners in Northern India - A Survey. The Internet Journal of Epidemiology. 2010;9(2):1-7.

**30.** Rashedi B, Petropoulos VC. Preclinical removable partial dentures curriculum survey. J Prosthodont 2003;12(2):116-123.

**31.** Basker R M, Davenport JC. A survey of partial denture design in general dental practice. J Oral Rehabil 1978;5(3):215-222.

**32.** Basker RM, Harrison A, Davenport JC, Marshall JL. Partial denture design in general dental practice - 10 years on. Br Dent J 1988;165(7):245-249.

**33.** Lynch CD, Allen PF. A survey of chrome-cobalt removable partial denture design in Ireland. Int J Prosthodont 2003;16(4):362-364.

**34.** Lynch CD, Allen PF. Quality of materials supplied to dental laboratories for the fabrication of cobalt chromium removable partial dentures in Ireland. Eur J Prosthodont Restor Dent 2003;11(4):176-180.

**35.** Lynch C D, Allen P F. Quality of written prescriptions and master impression for fixed and removable prosthodontics: a comparative study. Br Dent J 2005;198(1):17- 20.

**36.** Lynch C D, Allen P F. Why do dentists struggle with removable partial denture design? An investigation of educational and financial issues. Br Dent J 2006;200(5):277-281.

**37.** Sykora O, Calikkocaoglu S. Maxillary removable partial denture designs by commercial dental laboratories. J Prosthet Dentist 1970;23(6):633-40.

**38.** Lynch CD, Allen PF. The teaching of removable partial dentures in Ireland and the United Kingdom. Br Dent J 2007;203(8):E17.

**39.** Weintraub AM, Weintraub GS. The dental student as technician: An 18-year follow- up of preclinical laboratory programs. J Prosthodont 1997;6(2):128-136.

**40.** Wieder M, Faigenblum M, Eder A, Louca C. An investigation of complete denture teaching in the UK: Part 2. The DF1 experience. Br Dent J 2013; 215(5):229-236.

**41.** Ong CT, Pan N, Tiang R, et al. General dental practitioners' perceptions of removable prosthodontics in the undergraduate curriculum. N Z Dent J. 1999;95(421):80-83.

# Appendix A

**Questionnaire:**

**Please (√) wherever applicable.**

**Demographic variables**

**Gender:** Male ☐ Female ☐

**Age:**

**Nationality:**

**No. of years in dental practice:** < 5 yrs ☐ 5-9 yrs ☐

10-14 yrs ☐ 15-19 yrs ☐ >20yrs ☐

**What was the time allocated for pre-clinical removable prosthodontic training in your university?**

6 months ☐ 1 year ☐
2 years ☐ > 2 years ☐

**Are you able to apply your pre-clinical removable prosthodontic training in your clinical practice?**

Yes ☐ No ☐

**Do you perform removable prosthodontics procedures in your clinic**?

Yes ☐ No ☐

**If yes, answer the questions below:**

1. Manipulation of the impression material is done by me.
   a. Always ☐
   b. Sometimes ☐
   c. Never ☐

2. Pouring of the impressions is done by me.
   a. Always ☐
   b. Sometimes ☐
   c. Never ☐

3. Construction of the special trays is done by me.
   a. Always ☐
   b. Sometimes ☐
   c. Never ☐

4. Fabrication of the record bases and occlusal rims is done by me.
   a. Always ☐
   b. Sometimes ☐
   c. Never ☐

5. Artificial teeth arrangement for denture patients is done by me.
   a. Always ☐
   b. Sometimes ☐
   c. Never ☐

6. Processing (Acrylization) of the denture is done by me.
   a. Always ☐
   b. Sometimes ☐
   c. Never ☐

7. Designing of the partial denture framework is done by me.
   a. Always ☐
   b. Sometimes ☐
   c. Never ☐

8. If you are not satisfied by your dental technician's work, you correct it by yourself.
   a. Always ☐
   b. Sometimes ☐
   c. Never ☐

9. Do you track your dental technician's work to your satisfaction?
   a. Always ☐
   b. Sometimes ☐
   c. Never ☐

10. To what extent do you agree or disagree with this statement: "It would be better to dedicate more time on clinical prosthodontic training rather than pre-clinical removable prosthodontic lab training in undergraduate curriculum".
    a. Strongly agree ☐
    b. Agree ☐
    c. Neutral ☐
    d. Disagree ☐
    **e.** Strongly disagree ☐

Cumhuriyet Dental Journal, 26(1): 17-21, 2023
DOI: https://doi.org/10.7126/cumudj.1134687

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 | Available online, ISSN: 1302-5805 e-ISSN: 2146-2852 | Publisher: Sivas Cumhuriyet Üniversitesi

# *Morphologic Variations and Gender Dimorphism in Mandibular First Premolar Root Canal Pattern: A CBCT Study in South Indian Population*

**Nidhi James[1-a], Tina Puthen Purayil[1-b*], Vathsala Patil[2-c], Kalyana Chakravarthy Pentapati[3-d], Ravindranath Vineetha[2-e]**

[1] *Department of Conservative Dentistry and Endodontics, Manipal College of Dental Sciences, Manipal, Manipal Academy of Higher Education, Manipal, Karnataka, India*
[2] *Department of Oral Medicine and Radiology, Manipal College of Dental Sciences, Manipal, Manipal Academy of Higher Education, Manipal, Karnataka, India*
[3] *Department of Public health dentistry, Manipal College of Dental Sciences, Manipal, Manipal Academy of Higher Education, Manipal, Karnataka, India*
**Corresponding author*

**Research Article**

*History*

*Received: 26/06/2022*
*Accepted: 02/02/2023*



**ABSTRACT**

***Objective:*** The study aimed to evaluate the variations in the RCM of mandibular first premolars (MFP) in south Indians and also evaluated the gender dimorphism and contralateral symmetry of pattern.
***Methods:*** 200 Cone Beam Computed Tomography (CBCT) images of MFP of patients above 18 years were analysed for the root canal morphology after excluding the distorted images, endodontically treated tooth or fractured root. The teeth were carefully evaluated in cross sectional, axial and coronal sections and the information regarding the number of roots and the type of root canal as per Vertucci's classification. Interobserver and intraobserver reliability were also checked.
***Results:*** Single rooted teeth with Type I (73.01%) variation was the most prevalent pattern observed in the study population, which was followed by Type III (14.11%) and Type V (5.52%), respectively. Type IV and Type VIII variations were not found in our study.
***Conclusions:*** In both males and females, type I configuration was the most common pattern with symmetry in contralateral mandibular single-rooted first premolars.

***Key words:*** Cone Beam Computed Tomography, Mandible, Morphology, Premolar, Root Canal.

[a] mary.james.nj@gmail.com https://orcid.org/0000-0002-5351-5150
[b] tina.pp@manipal.edu https://orcid.org/0000-0002-8887-2297
[c] vathsala.mcods@manipal.edu https://orcid.org/0000-0002-8656-8080
[d] kalyan.cp@manipal.edu https://orcid.org/0000-0002-5462-5677
[e] vineetha.manu@manipal.edu https://orcid.org/0000-0002-8932-9982

*How to Cite: James N, Purayil TP, Patil V, Pentapati KC, Vineetha R. (2023) Morphologic Variations and Gender Dimorphism in Mandibular First Premolar Root Canal Pattern: A CBCT Study in South Indian Population, Cumhuriyet Dental Journal, 26(1):17-21.*

## Introduction

The maxillary and mandibular premolar teeth are known to have significant morphological variations in root canals compared to other teeth. It is reported more commonly in maxillary second premolars and mandibular first premolars.[1–4] A thorough knowledge and understanding of root canal morphology(RCM) is vital for the success of root canal therapy.[3,5,6]

Mandibular first premolars (MFP) have two pulp horns; a large buccal horn with sharp outline and an inconspicuous round lingual horn.[7] Access to the buccal root canal is easily achieved, whereas the lingual canal access is complicated due to the deviating path. The lingual inclination of these teeth also makes it difficult to locate the lingual orifice as the file insertion will be directed towards the buccal aspect of the tooth[8]. Moreover, frequent morphologic variations like C-shaped canals and extra root canals cause challenges in the biomechanical preparation and in obturation phases.[9–15]

Various methods have been used to identify and record the root canal morphologies, some of which are two-dimensional radiographs, staining methods for root canals, sectioning of the dental hard tissues, micro-CT, and CBCT (Cone-Beam Computed Tomography) scanning. CBCT is superior to traditional radiographs and other digital imaging methods.[16] The images procured by the CBCT are depicted in axial, sagittal, and coronal sections, and it also shows reduced superimposition by adjacent structures.

There is a general lack of literature on the variations in RCM of MFP in the south Indian population.[9,17–20] Hence, we aimed to evaluate the variations in RCM of MFP in the south Indian subpopulation. We also aimed to compare the root canal configurations with gender and symmetry considering the number of roots in MFP. The study aimed to evaluate the variations in the RCM of mandibular first premolars (MFP) in south Indians and also evaluated the gender dimorphism and contralateral symmetry of pattern.

## Material and Methods

A retrospective study on 200 CBCT images with MFP was conducted. We included CBCT images of individuals aged above 18 years with MFP. We have excluded images that were distorted, images with MFP which had endodontic treatment, fractured root, incomplete root formation, coronal or post endodontic restorations, and

physiological or pathological processes such as root resorption. A well-experienced radiologist performed CBCT imaging following the recommended protocol with the minimum exposure necessary for adequate image quality. CBCT images were obtained with i-CAT 17-19 Imaging System (Imaging Sciences International, USA). Exposure parameters were further adjusted according to patient indication for imaging. Image enhancement tools like zooming, contrast, and brightness adjustments, were used for better visualization and adjustment. Coronal, cross-sectional, and axial sections of the images were used to analyze the root morphology pattern. This study was conducted in the department of Oral Medicine and Radiology. The study protocol was approved by the institutional ethics committee, Kasturba Medical college and Kasturba Hospital, Manipal, India (Decision date- 8.10.2019, IEC no- 726/2019)

The CBCT images were assessed using Anatomage software under standard illumination conditions by a single trained radiologist. Repeat assessment of 10% images was done after one month. Also, 10% of the images were randomly evaluated by an experienced radiologist. A Kappa value of 0.7 was obtained, showing substantial inter and intra-observer reliability. Each image was studied based on the number of roots and the canal morphology in each root according to the Vertucci's classification.[21]

All the analysis was done using SPSS version 20. A p-value of <0.05 was considered statistically significant. Right, and left side variations, intra, and inter-examiner reliability were assessed using Kappa Coefficient. Comparison of RCM with sex was done using Fisher's exact test.

## Results

A total of 200 MFP were assessed for their RCM, out of which 102 were left MFP, 166 had single root, 33 had two roots, and one had three roots (Table 1). In both right and left MFP, Vertucci's Type-I was the most common root canal configuration present (69.6% and 93% respectively), followed by and Type V (12.5%) on the right side and Type III (12.3%) on the left side (Table 1).

In single-rooted teeth, the right and left distribution of various RCM was compared using the Kappa coefficient. There was a 74% similarity on the right and left side distribution of RCM (Kappa=0.39). The right and left distribution of RCM was done independently for buccal and lingual root canals in two rooted teeth. In the buccal root, the similarity was 54.54% (Kappa=0.058). However, a high similarity was seen in the lingual root (81.81%; Kappa = 0.421).

Significant differences were seen in the distribution of RCM of single-rooted teeth on both the sides. In both right and left MFP, the distribution of the type I pattern was significantly higher in females than males (P=0.046 and 0.041), respectively (Table 2). However, no significant differences were seen in the distribution of RCM of two rooted teeth with sex on both the sides in buccal and lingual root canals (Table 3).

## Discussion

The number of roots and root canal morphology in human population shows great diversity. Previous studies have utilized different methodologies to assess the root canal morphology and have reported complex internal anatomy of the MFP. Thorough knowledge of such variations in every population is indispensable. The advances in dental materials and diagnostic tools have along with thorough knowledge of canal morphology have increased the success rate of endodontic therapy, even in complex root canal configurations.[17,22]

Literature shows the presence of extra root and extra canals in the mandibular first premolar.[23,24] Present study showed that 79.8% of the teeth had a single root and 16.7% had two roots, and only one tooth had three roots. These observations were similar to previous studies. Studies done in India have reported that single RCM is the most common canal morphology.[19,25] Sert and Bayirli reported 60.5% with a single canal and 39.5% with two or more canals.[3] Singh and Pawar reported that 76% had a single canal, 22 had two canals, and 2% had three canals.[25] Trope *et al*. showed 89.1% to have single-rooted teeth, 10.9% to have two rooted teeth.[23] Yu *et al*. reported that 98% had a single root, and 2% had two roots.[9] Yang *et al*. reported 77.14% had single-rooted canals.[26]

Our study showed that Type I configuration (85.5%) is the most common pattern in MFP, which was in line with observations from the previous researches (50-88%) (Table 4).[3,9,27–35,10,17–21,25,26] This was followed by Type III configuration (13%), which was similar to study by Sert and Bayirli among the Turkish population.[3] However, these studies have reported that the 2nd most common pattern was C-shaped morphology. On the contrary present study, C-shaped configuration was noted in only 1% of the sample (Table 4).

Very few studies in the literature have evaluated the significant differences in RCM with respect to gender and quadrant wise distribution. We observed type I configuration to be the most commonly present configuration in both males and females on the right and left sides, which was in accordance to earlier reports.[3,33] The symmetry of RCM in contralateral premolars has been studied previously.[33,36,37] Our study also showed that in single-rooted teeth, there was 74% symmetry, while in two rooted teeth, it was only 55% in buccal and 82% in lingual root canals. This was lower than previous studies.[33,37] While one study reported that there were only a few pairs that showed such symmetry.[36]

Our sample showed one 3-rooted tooth, and 1% of the sample showed C-shaped canals. Previous studies have reported diverse and miscellaneous configurations like circumferential canals[30], Types like 1-3, 1-2-3, 2-1-3, and 2-1-2-1, [31] types 2-3, and 1-4.[20] However, such patterns were not reported in our sample. In both males and females, type I configuration was the most common pattern with symmetry in contralateral mandibular single-rooted first premolars. We used CBCT images to assess the variations in the RCM, which is superior to conventional

radiography and digital radiographic techniques. It is validated valuable tool to evaluate the complex canal morphology to improve the outcomes of endodontic therapy.

## Conclusions

In the present study using CBCT, Vertucci's Type I root canal configuration was the most common variant followed by Type III configuration and there was no difference noted in canal morphology variations when evaluated quadrant wise. Further studies on larger and different sub-populations are required to understand the canal morphological variations for better endodontic treatment outcomes and good prognosis.

## Acknowledgments

The authors would like to thank the Department of Oral Medicine and Radiology for their technical support in the study

## Conflicts of Interest

There are no conflicts of interest.

**Table 1.** Sample characteristics, number of roots and root canal morphology

| | Number of teeth | Number of roots | | | Root canal Morphology | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | Type I | Type II | Type III | Type V | Type VI | Type VII | C-shaped |
| Left | 102 | 82 | 20 | 0 | 93 (76.2) | 2 (1.6) | 15 (12.3) | 8 (6.6) | 0(0) | 3(2.5) | 1(0.8) |
| Right | 98 | 84 | 13 | 1 | 78(69.6) | 3(2.7) | 11(9.8) | 14(12.5) | 2(1.8) | 3(2.7) | 1(0.9) |
| Total | 200 | 166 | 33 | 1 | 171 | 5 | 26 | 20 | 2 | 6 | 2 |

**Table 2.** Comparison of root canal morphology with sex on right and left side in single rooted premolars (n=77)

| | Sex | | P-value |
|---|---|---|---|
| | Male | Female | |
| Left | N(%) | N(%) | |
| Type I | 27(69.2) | 34(89.5) | |
| Type II | 1(2.6) | 1(2.6) | |
| Type III | 8(20.5) | 1(2.6) | 0.041; Sig |
| Type V | 1(2.6) | 0(0) | |
| Type VII | 2(5.1) | 1(2.6) | |
| C | 0(0) | 1(2.6) | |
| Right | | | |
| Type I | 24(61.5) | 30(78.9) | |
| Type II | 2(5.1) | 1(2.6) | |
| Type III | 6(15.4) | 4(10.5) | |
| Type V | 4(10.3) | 0(0) | 0.046; Sig |
| Type VI | 0(0) | 2(5.3) | |
| Type VII | 3(7.7) | 0(0) | |
| C | 0(0) | 1(2.6) | |

**Table 3.** Comparison of root canal morphology with sex on right and left side in double rooted premolars (n=11)

| | | Sex | | P-value |
|---|---|---|---|---|
| | | Male | Female | |
| Buccal | | N(%) | N(%) | |
| Left | Type I | 5(83.3) | 4(80) | >0.99 |
| | Type III | 1(16.7) | 1(20) | |
| Right | Type I | 3(50) | 4(80) | 0.545 |
| | Type V | 3(50) | 1(20) | |
| Lingual | | | | |
| Left | Type I | 4(66.7) | 5(100) | - |
| | Type III | 1(16.7) | 0(0) | |
| | Type V | 1(16.7) | 0(0) | |
| Right | Type I | 4(66.7) | 5(100) | 0.455 |
| | Type V | 2(33.3) | 0(0) | |

**Table 4.** Review of root canal morphology from earlier studies

| Author | Year | Population | N | Method used | Root canal morphology (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | I | II | III | IV | V | VI | VII | VIII | Miscellaneous | C shaped |
| 1. Pineda et al | 1972 | Mexico | 202 | Radiograph | 69.3 | 0 | 4.9 | 1.5 | 23.4 | 0 | 0 | 0 | | |
| 2. Zillich & Dowson | 1973 | US | 1393 | Radiograph | 66 | 5.2 | 0 | 17.5 | 0 | 0 | 0 | 0.4 | 7.6^ | |
| 3. Vertucci | 1984 | US | 400 | D&C | 70 | 0 | 4 | 1.5 | 24 | 0 | 0 | 0 | | |
| 4. Baisden et al | 1992 | US | 100 | Sectioning | 76 | 0 | 0 | 24 | 0 | 0 | 0 | 0 | | |
| 5. Caliskan et al | 1995 | Turkey | 100 | D&C | 64.15 | 7.55 | 3.77 | 7.55 | 9.43 | 1.89 | 0 | 5.66 | | |
| 6. Sert & Bayirli | 2004 | Turkey | 200 | D&C | 60.5 | 18.5 | 11.5 | 7 | 2.5 | 0 | 0 | 1 | | |
| 7. Iyer et al* | 2006 | India | 2000 | RVG | 75.4 | 1 | | 20.8 | 2.4 | 0 | 0 | 0.4 | | |
| 8. Lu Tzu- Yi et al | 2006 | China | 82 | Sectioning | 54 | 6 | 6 | 10 | 0 | 0 | 0 | 0 | 6† | 18 |
| 9. Awawdeh & Al-Qudah | 2007 | Jordan | 500 | D&C | 58.2 | 4.8 | 1.4 | 14.4 | 16.8 | 0.8 | 1 | 0 | Type 1-3= 1<br>Type 1-2-3= 0.4<br>Type 2-1-3= 0.8<br>Type 2-1-2-1=0.4 | |
| 10. Velmurugan&Sandhya | 2009 | India | 100 | D&C | 72 | 6 | 3 | 10 | 8 | 0 | 0 | 0 | | 1 |
| 11. Jain & Bahuguna | 2011 | India | 138 | D&C | 67.39 | 7.97 | 3.62 | 2.89 | 17.39 | 0.72 | 0 | 0 | | |
| 12. Parekh et al | 2011 | India | 40 | D&C | 50 | 5 | 5 | 25 | 12.5 | 2.5 | 0 | 0 | | |
| 13. Yu et al. | 2012 | China | 174 | CBCT | 86.8 | 0 | 1.7 | 0 | 9.8 | 0 | 0 | 0.6 | | 1.1 |
| 14. Yang et al | 2013 | China | 440 | CBCT | 76.14 | 3.41 | 2.73 | 6.59 | 9.32 | 0 | 0 | 0.68 | | 1.14 |
| 15. Shetty et al | 2014 | India | 1186 | CBCT | 83.81 | 0.3 | 2.1 | 0.27 | 11.97 | 0.1 | 0 | 0.3 | 0.08‡ | 0.92 |
| 16. Singh and Pawar | 2014 | India | 100 | D&C | 80 | 6 | 0 | 10 | 2 | | | | | |
| 17. Abraham & Gopinath | 2015 | UAE | 100 | Clearing method | 65 | 2 | 3 | 13 | 14 | 0 | 0 | 0 | Type 2-3 = 1%<br>Type 1-4 = 2% | |
| 18. Alfawaz et al | 2019 | Saudi Arabia | 391 | CBCT | 88 | 3.6 | 3.1 | 2 | 1.5 | 0.3 | 0 | 1.5 | | |
| 19. Shrestha et al | 2019 | Nepal | 150 | D&C | 72 | 2.6 | 3.3 | 2.6 | 18.6 | 0 | 0 | 0 | 0.66†† | |
| 20. Present study | 2021 | India | 200 | CBCT | 85.5 | 2.5 | 13 | 0 | 11 | 1 | 3 | 0 | | 1 |

## References


1. Vertucci F, Seelig A, Gillis R. Root canal morphology of the human maxillary second premolar. Oral Surg Oral Med Oral Pathol 1974;38:456–464.
2. Sardar KP, Khokhar NH, Siddiqui I. Frequency of two canals in maxillary second premolar tooth. J Coll Physicians Surg Pakistan 2007;17:12–14.
3. Sert S, Bayirli GS. Evaluation of the root canal configurations of the mandibular and maxillary permanent teeth by gender in the Turkish population. J Endod 2004;30:391–398.
4. England MC, Hartwell GR, Lance JR. Detection and treatment of multiple canals in mandibular premolars. J Endod 1991;17:174–178.
5. Gulabivala K, Aung TH, Alavi A, Ng YL. Root and canal morphology of Burmese mandibular molars. Int Endod J 2001;34:359–370.
6. Martins JNR, Gu Y, Marques D, Francisco H, Caramês J. Differences on the Root and Root Canal Morphologies between Asian and White Ethnic Groups Analyzed by Cone-beam Computed Tomography. J Endod 2018;44:1096–1104.
7. Slowey RR. Root canal anatomy. Road map to successful endodontics. Dent Clin North Am 1979;23:555–573.
8. Vertucci FJ. Root canal morphology and its relationship to endodontic procedures. Endod Top 2005;10:3–29.
9. Yu X, Guo B, Li KZ, et al. Cone-beam computed tomography study of root and canal morphology of mandibular premolars in a western Chinese population. BMC Med Imaging 2012;12:18.
10. Baisden MK, Kulild JC, Weller RN. Root canal configuration of the mandibular first premolar. J Endod 1992;18:505–508.
11. Cooke HG, Cox FL. C-shaped canal configurations in mandibular molars. J Am Dent Assoc 1979;99:836–839.
12. Arayasantiparb R, Banomyong D. Prevalence and morphology of multiple roots, root canals and C-shaped canals in mandibular premolars from cone-beam computed tomography images in a Thai population. J Dent Sci 2021;16:201–207.
13. Brea G, Gomez F, Gomez-Sosa JF. Cone-beam computed tomography evaluation of C-shaped root and canal morphology of mandibular premolars. BMC Oral Health 2021;21:1–8.
14. Dou L, Li D, Xu T, Tang Y, Yang D. Root anatomy and canal morphology of mandibular first premolars in a Chinese population. Sci Rep 2017;7:1–7.
15. Fan B, Ye W, Xie E, Wu H, Gutmann JL. Three-dimensional morphological analysis of C-shaped canals in mandibular first premolars in a Chinese population. Int Endod J 2012;45:1035–1041.
16. Adarsh K, Sharma P, Juneja A. Accuracy and reliability of tooth length measurements on conventional and CBCT images: An in vitro comparative study. J Orthod Sci 2018;7.
17. Shetty A, Hegde MN, Tahiliani D, Shetty H, Bhat GT, Shetty S. A Three-Dimensional Study of Variations in Root Canal Morphology Using Cone-Beam Computed Tomography of

Mandibular Premolars in a South Indian Population. J Clin Diagn Res 2014;8:ZC22.
18. Jain A, Bahuguna R. Root canal morphology of mandibular first premolar in a gujarati population - an in vitro study. Dent Res J (Isfahan) 2011;8:118–122.
19. Velmurugan N, Sandhya R. Root canal morphology of mandibular first premolars in an Indian population: a laboratory study. Int Endod J 2009;42:54–8.
20. Abraham SB, Gopinath VK. Root canal anatomy of mandibular first premolars in an Emirati subpopulation: A laboratory study. Eur J Dent 2015;9:476.
21. Vertucci FJ. Root canal anatomy of the human permanent teeth. Oral Surg Oral Med Oral Pathol 1984;58:589–599.
22. Zhang W, Tang Y, Liu C, Shen Y, Feng X, Gu Y. Root and root canal variations of the human maxillary and mandibular third molars in a Chinese population: A micro-computed tomographic study. Arch Oral Biol 2018;95:134–140.
23. Trope M, Elfenbein L, Tronstad L. Mandibular premolars with more than one root canal in different race groups. J Endod 1986;12:343–345.
24. Cleghorn BM, Christie WH, Dong CCS. The root and root canal morphology of the human mandibular first premolar: a literature review. J Endod 2007;33:509–16.
25. Singh S, Pawar M. Root canal morphology of South asian Indian mandibular premolar teeth. J Endod 2014;40:1338–1341.
26. Yang H, Tian C, Li G, Yang L, Han X, Wang Y. A cone-beam computed tomography study of the root canal morphology of mandibular first premolars and the location of root canal orifices and apical foramina in a Chinese subpopulation. J Endod 2013;39:435–438.
27. Pineda F, Kuttler Y. Mesiodistal and buccolingual roentgenographic investigation of 7,275 root canals. Oral Surg Oral Med Oral Pathol 1972;33:101–110.
28. Zillich R, Dowson J. Root canal morphology of mandibular first and second premolars. Oral Surg Oral Med Oral Pathol 1973;36:738–744.
29. Çalişkan MK, Pehlivan Y, Sepetçioğlu F, Türkün M, Tuncer SŞ. Root canal morphology of human permanent teeth in a Turkish population. J Endod 1995;21:200–204.
30. Lu TY, Yang SF, Pai SF. Complicated Root Canal Morphology of Mandibular First Premolar in a Chinese Population Using the Cross Section Method. J Endod 2006;32:932–6.
31. Awawdeh LA, Al-Qudah AA. Root form and canal morphology of mandibular premolars in a Jordanian population. Int Endod J 2008;41:240–248.
32. Parekh V, Shah N, Joshi H. Root canal morphology and variations of mandibular premolars by clearing technique: an in vitro study. J Contemp Dent Pract 2011;12:318–321.
33. Alfawaz H, Alqedairi A, Al-Dahman YH, et al. Evaluation of root canal morphology of mandibular premolars in a Saudi population using cone beam computed tomography: A retrospective study. Saudi Dent J 2019;31:137–142.
34. Shrestha R, Srii R, Shrestha D. Diversity of root canal morphology in mandibular first premolar. Kathmandu Univ Med J 2019;17:223–228.
35. Habib AA, Kalaji MN, Al Saysd TJ, Al Jawfi KA. Root canal configurations of the first and second mandibular premolars in the population of north Syria. J Taibah Univ Med Sci 2015;10:391–395.
36. Xu J, Shao MY, Pan HY, et al. A proposal for using contralateral teeth to provide well-balanced experimental groups for endodontic studies. Int Endod J 2016;49:1001–8.
37. Johnsen GF, Dara S, Asjad S, Sunde PT, Haugen HJ. Anatomic Comparison of Contralateral Premolars. J Endod 2017;43:956–963.

Cumhuriyet Dental Journal, 26(1): 22-27, 2023
DOI: https://doi.org/10.7126/cumudj.1200254

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 | Available online, ISSN: 1302-5805 e-ISSN: 2146-2852 | Publisher: Sivas Cumhuriyet Üniversitesi

# *Association of Burnout with Socio-Educational Variables in a Sample of Chilean Dental Students*

**Javiera Cárdenas-Retamal[1-a], Valeria Campos[2-b], Ricardo Cartes-Velásquez[3-c*]**

[1] *Private practice, Los Ángeles, Chile*
[2] *Universidad de Concepción School of Dentistry, Concepción, Chile*
[3] *Universidad de Concepción School of Medicine, Concepción, Chile*
**Corresponding author*

**Research Article**

*History*

*Received: 14/11/2022*
*Accepted: 08/02/2023*



**ABSTRACT**

***Objective:*** To assess the association of burnout with socio-educational variables in a sample of Chilean dental students

***Material and Methods:*** A cross-sectional study was carried out on dental students in their 4th/5th years of Universidad de Concepción. The following variables were considered: sociodemographic (sex, age, with whom the student lives and commune of origin), educational (course, course failure, number of years behind and their cause, number of career options, funding, and secondary school type), and burnout using the Burnout-MBI-SS (Maslach's Burnout Inventory for students). Descriptive statistics were made, Shapiro-Wilk test was used to assess normality, as non-normal distribution was verified for MBI-SS, Mann-Whitney and Kruskal-Wallis was used to estimate statistical differences amongst categorical variables, and Spearman for correlations.

***Results:*** Most students were in 4th year, female with a mean age of 23. For the majority, dental school was their first option, and were studying with a scholarship. Most of them lived with their nuclear family and 58% had at least failed one course. MBI subscales' levels distribution is as follows: Emotional exhaustion (EE, 16.47% low, 31.76% moderate, and 51.76% high), Depersonalization (DP, 18.82% low, 24.71% moderate, and 56.47% high), and Personal accomplishment (PA, 7.65% low, 31.76% moderate, and 60.59% high). Statistical significant correlations were only found for Depersonalization with students' age (rho= 0.2420) and reprobation years (rho= 0.1838).

***Conclusions:*** Dental students from the University X, which are female, attending their fifth year, and students who failed courses, especially clinical ones, exhibit higher levels of burnout.

***Key words:*** Burnout, Professional; Dental Students; Dental Education.

a javicardenasret@gmail.com https://orcid.org/ 0000-0002-1539-0414 b valeriacamposcannobbio@gmail.com https://orcid.org/ 0000-0003-0697-1345
c cartesvelasquez@gmail.com https://orcid.org/0000-0001-5831-7324

*How to Cite: Cárdenas-Retamal J, Campos V, Patil V, Cartes-Velásquez R. (2023) Association of Burnout with Socio-Educational Variables in a Sample of Chilean Dental Students, Cumhuriyet Dental Journal, 26(1):22-27.*

## Introduction

Work and academic activities are by themselves a source of stress[1-3], whereas dental practice is one of the health professions that produce more anxiety.[4,5] Stress has also been described in students, whereas dental students report higher levels of stress than medical students.[6] In addition to stress, a phenomenon typical of those who work in personal care has been described: burnout.[7] Burnout is *"a syndrome of emotional fatigue, depersonalization and low personal fulfillment, which can occur among individuals who work with people"* and which originates as a prolonged response of the body to environmental factors to which it cannot adapt.[5,8] This syndrome mainly affects professionals and students who are more committed to a humanistic philosophy of work in direct contact with people.[9,10]

Students who suffer burnout are more predisposed to the use of medications to control anxiety, manage cognitive performance problems, and regulate sleep problems or symptoms of depression.[11] If burnout is not treated in time, it could be a precursor to deterioration in mental health, leading to long-term depression and suicide.[9,12,13] Dental students present high rates of burnout as a consequence of highly demanding professional training, accompanied by high fees and difficult recovery of investment, which translates into high levels of dissatisfaction with low personal fulfillment.[14,15] Moreover, during clinical courses the students must develop skills such as therapeutic and psychological management of the complex dental patient (who may experience anxiety, pain, and fear) which increases burnout levels.[5,14,16]

Burnout in dental students is mainly related to social and educational factors.[5,12-15] Though there are studies in Chile that explored most of these variables, the impact on burnout levels of the separation of the student from his family when studying in another city, course reprobation, or type of funding is lacking.[15-19] Thus, this paper aims to determine the association of burnout with socio-educational variables in a sample of Chilean dental students.

## Material and Methods

### *Study design, settings, and participants*

A cross-sectional study was carried out, including dental students from the Universidad de Concepción, corresponding to the 4th/5th year, as in those years dental students begin their clinical courses. The Universidad de Concepción is one of the oldest, most traditional, and prestigious universities in Chile, the 2nd biggest city in Chile.

All students who were enrolled in clinical courses were included, regardless of whether they have failed any course. Exchange students were excluded because they are exposed to different risk factors and the language and cultural barrier of the version of the instrument. There was no sample size calculation, as the target was the whole population.

### *Variables*

The data collection included sociodemographic variables: sex (female/male), age (in years), with whom the student lives (nuclear family/extended family/student room) and commune of origin (name of the commune); and educational variables: course (fourth or fifth year), course failure (yes/no) number of years behind (in years) and their cause (clinical/practical/theory), number of career option (1st/ 2nd/3rd), funding (loan/free grant/loan + free grant/self-funding/other), and secondary school type (Public/Private/Subsidized); and burnout using the Maslach's Burnout Inventory for students (MBI-SS). MBI-SS had been extensively used to assess burnout amongst health students, thus it was choosen for comparison with other studies.[7-19]

The MBI-SS validated in Chile[17] was used. The MBI-SS measures the 3 aspects of the syndrome: emotional fatigue, depersonalization, and personal fulfillment. The emotional exhaustion subscale consists of 7 questions and assesses the experience of being emotionally exhausted by the demands of work, the maximum score is 42 points. Similarly, the depersonalization subscale is made up of 7 questions and assesses the degree to which each one recognizes attitudes of coldness and detachment, the maximum value is 42 points. Finally, the lack of personal fulfillment subscale is made up of 8 items, which assess feelings of self-efficacy and personal fulfillment at work. the maximum value is 48. To consider the presence of Burnout Syndrome, high scores are considered for emotional fatigue and depersonalization and low for personal fulfillment. MBI-SS subscales were categorized in three levels: low, moderate and high, as suggested in the Maslach Burnout Inventory Manual.[20] There is not widely accepted cutoff points to diagnose burnout using MBI-SS, thus the results are shown for subscales levels.

### *Measurement*

The students participated freely by previously signing an informed consent. Two researchers collected sociodemographic data and the application of the instrument through an self-applied survey. Students were contacted in the classroom, at the beginning of theory or clinical activities, during the first two months of the second semester of 2019. Each course was visited twice in case a student was absent the first time. There was no monetary nor academic compensation associated with participation.

### *Ethics*

This study was authorized by the Bioethics Committee of the School of Dentistry of the Universidad de Concepción (C.E.C. N °016/ 18).

### *Data analysis*

Data were tabulated in MS Excel (Microsoft Corp., USA) and then analyzed with STATA 10/SE (Stata Corp., USA). Descriptive statistics for quantitative were made using mean and standard deviation for normal distribution variables, and median and interquartile range for non-normal distribution variables; for categorical variables, frequency and percentage distribution were calculated. Shapiro-Wilk test was used to assess normality, as non-normal distribution was verified for MBI-SS and its subscales, Mann-Whitney and Kruskal-Wallis was used to estimate statistical differences amongst categorical variables, and Spearman for correlations ($p < 0.05$).

## Results

One-hundred and seventy dental students were included as they answered the entire survey, 65.88% were women, and the age mean was 23.14 years, with a participation rate of 87%. The characterization of the sample is shown in Table 1.

MBI subscales' levels distribution is as follows: Emotional exhaustion (EE, 16.47% low, 31.76% moderate, and 51.76% high), Depersonalization (DP, 18.82% low, 24.71% moderate, and 56.47% high), and Personal accomplishment (PA, 7.65% low, 31.76% moderate, and 60.59% high). MBI subscales have non-normal distribution ($p < 0.05$), thus, non-parametric tests were used to assess statistical significance. MBI subscales' scores by socio-educational variables are shown in Table 2. Statistically significant correlations were only found for DP and students' age ($rho = 0.2420$, $p = 0.0015$) and reprobation years ($rho = 0.1838$, $p = 0.0164$).

## Discussion

More than half of the surveyed students present high levels of burnout considering the MBI-SS subscales, which is very worrying since the data was collected at the beginning of the academic year. This situation implies that the syndrome is not resolved even with a (summer) break from the stressor but is a prolonged response of the body where its well-being is affected.[21,22]

Entering the clinical stage requires the student to have clinical and cognitive skills that allow them to solve oral health problems.[10] This can lead to high/unsustainable

levels of stress due to working under constant time pressure, completing jobs on a scheduled basis, performing repetitive work, and enduring stress led by uncooperative and anxious patients.[21,22] To avoid increased stress in students and prevent burnout syndrome, better curricular planning and administration, as well as progressive and early contact with patients, are necessary.[15]

Regarding the sociodemographic variables, no statistically significant results were found, which is consistent with the study by Barraza *et al.*[23] However, it is relevant to mention that studies such as that of Mohebbi *et al.*[24] show that financial support from family and residential status (living without parents) is associated with greater emotional exhaustion in students. These factors are likely to be determining factors in the appearance of burnout in early years students, who must go through a period of adaptation to changes in their lives, such as leaving the parents' home, who act as a psychological supporter in the face of difficulties.[25,26]

Regarding the choice of a career in dentistry, no significant differences were found in burnout levels between those for whom dentistry was the first choice and those who were not. This agrees with the results of Jiménez-Ortiz *et al.*[26], unlike Mafla *et al.*[14], who found higher levels of burnout among those who did not choose dentistry as their first choice. These differences are probably influenced by social factors specific to each region, especially in terms of the social value of being a dentist. While the type of secondary school of origin was not associated with differences in burnout levels, similar to the study by Muñoz *et al.*[16] in this same university.

The literature shows dissimilar results regarding differences by sex, and there is no agreement if it affects more women or men.[12,25-27] The women surveyed presented higher levels of emotional exhaustion, similar to the study by Muñoz *et al.*[18], this could be explained by the social constructs of masculinity, in which men are repressed in terms of expressing their emotions.

Those students who failed any course(s), especially clinical courses, have more depersonalization than the rest of the students, feeling little empathetic about their work and their patients. This result is contradictory to Parra-Sandoval *et al.*[28], who did not find any difference in the stress levels of those who had failed and those who had not. More research is needed on the effects of failure on burnout levels and the mental health of dental students.

Depersonalization can lead to dental students centering their attention only on completing the number of clinical requirements to approve the course[29]. Moreover, dental programs do not usually promote soft skills such as empathy or social responsibility[30,31] in their curricula, which can worsen the situation. The above could explain the findings of Irfan *et al.*[32] where only half of the dental students reported high levels of empathy, the empathy decline that has been observed in dental students during their first year of training[5], and the empathy level decreased as patient exposure increased.[33] The latter is a worrying situation as it overlooks their patients' needs and their social role and commitment to their community[31] thus, generating future dental professionals with low empathy and commitment to their role in society.

Worldwide, one of the main sources of stress in dental programs is course failing[34] and facing their parents after course failure[35] which can lead to burnout. This could be due to that, as most dental program only promotes hard skills, neglecting self-confidence, and positive attitudes, among others.[9] In addition, as dental students usually hold a previously successful academic track in high school, such as being Valedictorians, may not be able to fulfill their previous high standards.[16] As emotional intelligence is the cornerstone of soft skills, its development in dental students should be stressed out.[9] Given the above, different interventions have been successfully implemented in dental programs aimed at reducing burnout such as Yoga to reduce stress[36], courses to enhance emotional intelligence[37], or strengthening personal confidence.[38] Yet future research is needed to decrease burnout, promoting the development of emotional intelligence, as it can help tolerate stress and minimize burnout levels[39] and has a strong correlation with empathy.[32]

Burnout has a complex origin, it is not only a lack of resilience or vocation in students but also the social environment and the characteristics of the educational institution are involved.[13,23] Ensuring an environment that provides a good level of quality of life to the student could lead to them feeling more satisfied and with lower levels of stress. This would allow their self-efficacy to be higher and they engage with greater dedication, effort, and perseverance in their studies.[14,19,40]

Some limitations must be considered: the sample represents only one institution; thus it is difficult to extrapolate these results to other settings. The sample selection was not probabilistic, which might have affected the results; and, these results do not implicate causality, but offer initial evidence on the impact of socio-educational variables on burnout levels for dental students.

## Conclusions

Dental students from Universidad de Concepción, which are female, attending their fifth year, and students who failed courses, especially clinical ones, exhibit higher levels of burnout.

## Funding

None.

## Conflicts of Interest

None.

**Table 1.** Characterization of the sample.

| Variable | 4th year | 5th year | General |
|---|---|---|---|
| Sex | | | |
| Female, n (%) | 73 (70.19) | 39 (59.09) | 112 (65.88) |
| Male, n (%) | 31 (29.81) | 27 (40.91) | 58 (34.12) |
| Age, years (SD) | 22.70 (2.19) | 23.83 (2.58) | 23.14 (2.41) |
| Dentistry as first option, n (%) | 55 (52.88) | 36 (54.55) | 91 (53.53) |
| Funding | | | |
| Loan | 13 (12.50) | 10 (15.15) | 23 (13.53) |
| Scholarship | 48 (46.15) | 24 (36.36) | 72 (42.35) |
| Loan + Scholarship | 22 (21.15) | 18 (27.27) | 40 (23.53) |
| Self-funding | 16 (15.38) | 9 (13.64) | 25 (14.71) |
| Other | 5 (4.81) | 5 (7.58) | 10 (5.88) |
| Secondary school type | | | |
| Public | 23 (22.12) | 13 (19.7) | 36 (21.18) |
| Private | 20 (19.23) | 10 (15.15) | 30 (17.65) |
| Subsidized | 61 (58.65) | 43 (65.15) | 104 (61.18) |
| Live with | | | |
| Nuclear family, n (%) | 75 (72.12) | 40 (60.61) | 115 (67.65) |
| Extended family, n (%) | 5 (4.81) | 7 (10.61) | 12 (7.06) |
| Student room, n (%) | 24 (23.08) | 19 (28.79) | 43 (25.29) |
| Reprobation rate, n (%) | 56 (53.85) | 43 (65.15) | 99 (58.24) |
| Reprobation years, mean (SD) | 0.95 (1.21) | 1.03 (1.05) | 0.98 (1.15) |
| Reprobation motive | | | |
| Theory | 21 (37.50) | 17 (39.53) | 38 (38.38) |
| Practice | 6 (10.71) | 5 (11.63) | 11 (11.11) |
| Clinics | 16 (28.57) | 15 (34.88) | 31 (31.31) |
| More than one motive | 13 (23.21) | 6 (13.95) | 19 (19.19) |

SD: standard deviation

**Table 2.** MBI subscales' scores by categorical socio-educational variables.

| Variable | EE score (IQR) | DP score (IQR) | PA score (IQR) |
|---|---|---|---|
| Course | *p = 0.8930* | *p = 0.0142* | *p = 0.0475* |
| 4th | 27 (22-32) | 10 (6-16) | 33 (28-36) |
| 5th | 25 (21-33) | 13.5 (7-20) | 30.5 (24-35) |
| Sex | *p = 0.0008* | *p = 0.5714* | *p = 0.1793* |
| Female | 28 (23-34) | 10.5 (6-19) | 31 (25.5-36) |
| Male | 24 (15-29) | 12 (6-17) | 33 (29-36) |
| Dentistry | *p = 0.4690* | *p = 0.8169* | *p = 0.8867* |
| First career option | 28 (21-34) | 12 (7-19) | 32 (26-36) |
| Second or greater | 26 (22-32) | 10 (6-19) | 32 (28-36) |
| Funding | *p = 0.7698* | *p = 0.2868* | *p = 0.9385* |
| Loan | 27 (20-32) | 16 (6-21) | 31 (26-35) |
| Scholarship | 27.5 (22-33) | 10.5 (6-18) | 33 (27-36) |
| Loan + Scholarship | 27 (24-30.5) | 12.5 (8-19) | 31 (25-36) |
| Self-funding | 23 (20-34) | 9 (8-13) | 32 (27-36) |
| Other | 29 (27-32) | 9 (6-11) | 30.5 (28-36) |
| Secondary school type | *p = 0.1413* | *p = 0.3151* | *p = 0.3809* |
| Public | 24.5 (14-30.5) | 9 (6-17) | 33 (30-36) |
| Private | 24.5 (20-34) | 9.5 (7-17) | 32.5 (27-36) |
| Subsidized | 28 (23-32.5) | 12.5 (6-19) | 31 (25-35.5) |
| Live with | *p = 0.6321* | *p = 0.7888* | *p = 0.8986* |
| Nuclear family | 27 (22-32) | 11 (7-19) | 32 (27-36) |
| Extended family | 27.5 (23.5-33.5) | 10 (4.5-18.5) | 31 (27-35) |
| Student room | 25 (15-34) | 13 (5-19) | 33 (25-35) |
| Reprobation | *p = 0.9686* | *p = 0.0206* | *p = 0.3352* |
| Yes | 27 (23-31) | 13 (7-19) | 31 (26-35) |
| No | 27 (20-34) | 9 (5-16) | 33 (27-37) |
| Reprobation motive | *p = 0.6358* | *p = 0.0180* | *p = 0.5665* |
| Theory | 27.5 (23-35) | 9.5 (6-17) | 31 (25-35) |
| Practice | 24 (20-29) | 11 (9-19) | 31 (28-34) |
| Clinics | 28 (23-33) | 18 (12-21) | 31 (26-35) |
| More than one motive | 24 (21-29) | 12 (6-17) | 33 (31-36) |

SD: standard deviation. IQR: interquartile range. EE: emotional exhaustion. DP: depersonalization. PA: personal accomplishment.

## References


1. Melita A, Cruz M, Merino J. Burnout en profesionales de enfermería que trabajen en centros asistenciales de la VII región, Chile. Cienc Enferm. 2008;14(2):75-85.
2. Kilic R, Nasello JA, Melchior V, Triffaux JM. Academic burnout among medical students: respective importance of risk and protective factors. Public Health. 2021 Sep;198:187-195. doi: 10.1016/j.puhe.2021.07.025. Epub 2021 Sep 1. PMID: 34478954.
3. Bridgeman PJ, Bridgeman MB, Barone J. Burnout syndrome among healthcare professionals. Am J Health Syst Pharm. 2018 Feb 1;75(3):147-152. doi: 10.2146/ajhp170460. Epub 2017 Nov 28. PMID: 29183877.
4. Jain A, Bansal R. Stress among Medical and Dental Students: a Global Issue. J Dent Med Sc. 2012;1(5):05-07.
5. Pérez F, Cartes-Velásquez R. Estrés y burnout en estudiantes de Odontología: una situación preocupante en la formación profesional. Edumecentro. 2015;7(2):179-190.
6. Abbasi SZ, Mubeen N, Ayub T, Khan MA, Abbasi Z, Baig N. Comparison of stress levels among medical and dental students in the clinical years of training and their coping strategies. J Pak Med Assoc. 2020 Jun;70(6):1006-1008. doi: 10.5455/JPMA.294959. PMID: 32810097.
7. Freudenberger HJ. Staff burnout. J Soc Issues 1974;30:15965.
8. Gill-Monte P. Factorial Validity of the Maslach Burnout Inventory (MBI-HSS) among spanish professionals. Rev Saúde Pública. 2005;39(1):1-8.
9. Nangle MR, Henry JD, von Hippel C, Kjelsaas K. An empirical study of how emotion dysregulation and social cognition relate to occupational burnout in dentistry. Br Dent J. 2019;227(4):285-290. doi: 10.1038/s41415-019-0620-0.
10. Álvarez J, Cruz D. El burnout académico y el engagement en estudiantes de quinto año de Estomatología. Edumecentro. 2018;10(4):37-53.
11. Assunção H, Marôco J. Utilização de medicamentos em estudantes universitários com Burnout. Psic., Saúde & Doenças. 2020;21(1):15-21. doi: http://dx.doi.org/10.15309/20psd210104.
12. Peralta-Ayala R, Moya T. Síndrome de Burnout en estudiantes de Odontología. Dominio de las Ciencias. 2017;3(1):432-442. doi: 10.23857/dom.cien.pocaip.2017.3.1.432-442
13. Bitran M, Zúñiga D, Pedrals N, Echeverría G, Vergara C, Rigotti A, Puschel K. Burnout en la formación de profesionales de la salud en Chile: Factores de protección y riesgo, y propuestas de abordaje desde la perspectiva de los educadores. Rev. méd. Chile. 2019;147(4):510-517. doi: http://dx.doi.org/10.4067/S0034-98872019000400510
14. Mafla A, et al. Burnout prevalence and correlates amongst Colombian dental students: the STRESSCODE study. Eur J Dent Educ. 2015;19(4):242-250. doi: 10.1111/eje.12128
15. Misrachi-Launert Clara, et al. Fuentes de estrés percibidas y rendimiento académico de estudiantes de odontología chilenos. FEM. 2015;18(2):109-116. doi: http://dx.doi.org/10.4321/S2014-98322015000200006
16. Muñoz F, Medina A, Carrasco D, Pérez C, Ortiz L. Burnout en estudiantes de Odontología y su relación con sus características sociodemográficas y antecedentes académicos. Educación Médica Superior. 2016;30(2).
17. Pérez C, Parra P, Fasce E, Ortiz L, Bastías N, Bustamante C, et al. Estructura factorial y confiabilidad del Inventario de burnout de Maslach en universitarios chilenos. Revista Argentina de Clínica Psicológica. 2012;21(3):255-263.
18. Muñoz F, Medina A, Carrasco D, Pérez C, Ortiz L. Antecedentes académicos como predictores de Burnout en estudiantes de primer año de Odontología. Educación Médica Superior. 2017;31(2).
19. Dávila A, Ruiz R, Moncada L, Gallardo I. Niveles de ansiedad, depresión y percepción de apoyo social en estudiantes de Odontología de la Universidad de Chile. Revista de Psicología. 2011;20(2):147-172.
20. Maslach C, Jackson SE, Leiter MP: Maslach burnout inventory manual. 1996, Moutain View, CA: CCP, Inc, Third
21. Collin V, Toon M, O'Selmo E, Reynolds L, Whitehead P. A survey of stress, burnout and well-being in UK dentists. Br Dent J. 2019;226(1):40-49. doi: 10.1038/sj.bdj.2019.6.
22. Elani HW, Allison PJ, Kumar RA, Mancini L, Lambrou A, Bedos C. A systematic review of stress in dental students. J Dent Educ. 2014;78(2):226-242.
23. Barraza A, González LA, Garza A, Cázares de León F. El estrés académico en alumnos de odontología. Revista Mexicana de Estomatología. 2019;6(1):12-26.
24. Mohebbi SZ, Yazdani R, Talebi M, Pakdaman A, Heft MW, Bahramian H. Burnout among Iranian dental students: psychometric properties of burnout clinical subtype questionnaire (BCSQ-12-SS) and its correlates. BMC med Educ. 2019;19(1):388. doi: https://doi.org/10.1186/s12909-019-1808-3
25. Picasso-Pozo M, Huillca-Castillo N, Ávalos-Márquez J, Omori-Mitumori E, Gallardo-Schultz A, Salas-Chávez M. Síndrome de burnout en estudiantes de Odontología de una universidad peruana. KIRU. 2012;9(1).
26. Jiménez-Ortiz JL, Islas-Valle RM, Jiménez-Ortiz JD, Pérez-Lizárraga E, Hernández-García ME, González.Salazar F. Emotional exhaustion, burnout, and perceived stress in dental students. J Int Med Res. 2019;47(9):4251-4259. doi: https://doi.org/10.1177/0300060519859145
27. Singh P, Aulak DS, Mangat SS, Aulak MS. Systematic review: factors contributing to burnout in dentistry. Occup Med (Lond). 2016;66(1):27-31.
28. Parra-Sandoval JM, Rodríguez-Álvarez D, Rodríguez-Hopp MP, Díaz-Narváez V. Relación entre estrés estudiantil y reprobación. Rev Salud Uninorte 2018;34(1):47-57.
29. Badran DH, Al-Ali MH, Duaibis RB, Amin WM. Burnout among clinical dental students at Jordanian universities. East Mediterr Health J. 2010;16(4):434-7.
30. Carvajal M, López S, Sarabia-Alvarez P, Fontealba J, Padilla M, Sumi J, et al. Empathy Levels of Dental Faculty and Students: A survey Study at an Academic Dental Institution in Chile. J Dent Educ. 2019; 83(10): 1134-1141. doi: https://doi.org/10.21815/JDE.019.124
31. Alcota M, Ruiz de Gauna P, González F. Development of ethical practices and social responsibility in dental education at the university of Chile: student and faculty perceptions. Eur J Dent Educ. 2013; 17(1): e70-6. doi: https://doi.org/10.1111/j.1600-0579.2012.00767.x
32. Irfan M, Saleem U, Sethi MR, Abdullah AS. Do We Need To Care: Emotional Intelligence And Empathy Of Medical And Dental Students. J Ayub Med Coll Abbottabad. 2019 Jan-Mar;31(1):76-81. PMID: 30868789.
33. Narang R, Mittal L, Saha S, Aggarwal VP, Sood P, Mehra S. Empathy among dental students: A systematic review of literature. J Indian Soc Pedod Prev Dent. 2019;37(4):316-326. doi: 10.4103/JISPPD.JISPPD_72_19. PMID: 31710004.
34. Fonseca J, Divaris K, Villalba S, Pizarro S, Fernandez M, Codjambassis A, Villa-Torres L, Polychronopoulou A. Perceived sources of stress amongst Chilean and Argentinean dental students. Eur J Dent Educ. 2013;17(1):30-8. doi: 10.1111/eje.12004. PMID: 23279390.

**35.** Acharya S. Factors affecting stress among Indian dental students. J Dent Educ 2003: 67: 1140–1148. https://doi.org/10.1002/j.0022-0337.2003.67.10.tb03707.x

**36.** Partido BB, Stefanik D. Impact of emotional intelligence training in a communication and ethics course among second-year dental students. J Dent Educ. 202084(6):704-711. doi: 10.1002/jdd.12142.

**37.** Partido BB, Owen J. Relationship between emotional intelligence, stress, and burnout among dental hygiene students. J Dent Educ. 2020;84(8):864-870. doi: 10.1002/jdd.12172. PMID: 32359093.

**38.** Alcota M, Fuenzalida A, Barrientos C, Garrido M, Ruiz de Gauna P, González FE. An "XL" endodontics intervention for dental students required to repeat the course: changing frustration to improved grades and attitudes. J Dent Educ. 2015;79(4):399-408. PMID: 25838011.

**39.** Braun SE, Deeb G, Carrico C, Kinser PA. Brief Yoga Intervention for Dental and Dental Hygiene Students: A Feasibility and Acceptability Study. J Evid Based Integr Med. 2019;24:2515690X19855303. doi: 10.1177/2515690X19855303.

**40.** Martos África, et al. Burnout y engagement en estudiantes de Ciencias de la Salud. Eur J Pshychol Educ. 2018;8(1):23-36.

Cumhuriyet Dental Journal, 26(1): 28-32, 2023
DOI: https://doi.org/10.7126/cumudj. 1202436

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 | Available online, ISSN: 1302-5805 e-ISSN: 2146-2852 | Publisher: Sivas Cumhuriyet Üniversitesi

# *Evaluation of Flexural Strength of Different All-Ceramic Porcelain Systems*

**Akın Coşkun**[1-a*]

[1] *Department of Prosthodontics, Faculty of Dentistry, University of Dokuz Eylül, Izmir, Türkiye*
**Corresponding author*

**Research Article**

*History*

*Received: 10/11/2022*
*Accepted: 01/02/2023*



**ABSTRACT**

Statement of problem protective and restorative dentistry's basic function is to protect the continuity and integrity of the tissues and to restore function, phonation, and esthetics lost due to any cause. The success of dental ceramics is affected by flexural strength, but little data are available on their clinical performance.

***Purpose:*** This study evaluated the flexural strength of the Finesse, In-Ceram Zirconia and In-Ceram Alumina press all-ceramic porcelain systems. The success of dental porcelains is partly related to their flexural strength. Flexural strength values of three porcelain Systems were measured to include Finesse, In-Ceram Zirconia and In-Ceram Alumina press all ceramic porcelain systems.

***Material and Methods:*** The flexural strengths of the three porcelain systems were determined by employing the method ISO specification 6872. For the statistical evaluations of the flexure strength values, Mann-Whitney U and Kruskal Wallis tests were used.

***Results:*** When the flexural strengths of Finesse, In-Ceram Zirconia and In-Ceram Alumina groups were compared, the diversity were found to be statistically significant.

***Conclusions:*** The highest flexural strength was observed for In-Ceram Zirconia, followed by In-Ceram Alumina and Finesse porcelain system.

***Clinical implications:*** In this study, Finesse, In-Ceram Zirconia, and In-Ceram Alumina all-ceramic systems were compared concerning flexural strength. The diversity between the groups are significant ($p<0.05$).

***Key words:*** Flexural Strength, All-Ceramic Porcelain Systems, Finesse, In-Ceram Zirconia and In-Ceram Alumina.

[a] *akin.coskun@deu.edu.tr* *https://orcid.org/0000-0001-6718-9504*

*How to Cite: Coşkun A. (2023) Evaluation of Flexural Strength of Different All-Ceramic Porcelain Systems, Cumhuriyet Dental Journal, 26(1):28-32.*

## Introduction

In recent years, new porcelain treatment methods have been developed for prosthetic dentistry.[1] Porcelains used in dental practice are known for their natural structure, optical transmittance and most importantly their durability.[2] In addition to the aesthetic and physical properties of porcelain restorations, their resistance to physical bending is also important.[3]

Due to the low permeability of the metal structure that creates the durability in metal-supported porcelain used in dentistry, aesthetic problems and problems may be experienced on the durability of the porcelain part. Finesse all-ceramic porcelain systems are created using the hot press technique[4], slip-cast technique for Zirconia porcelain and another by a Alumina pocelain has recently been introduced to form all-ceramic structures for use in prosthetic restorations. In 1985, Dr. An all-ceramic structure known as slip cast was developed by Sadoon in his laboratory in Paris.[3]

Tests on flexural strength and durability are carried out on newly developed porcelain structures using in vitro test techniques without conducting clinical studies.[6] The main advantage of the bending test is that a pure tensile strength State can be created on one side of the sample. Three- and four-point bending stress tests have also been used for the strength evaluation of dental biomaterials.[7] Such tests are frequently used because samples with simple shapes (bars or rods) can be used, and no special grips are required.[8]

The success of dental porcelains is partly related to their flexural strength. This study evaluated the flexural strength of the Finesse, In-Ceram Zirconia and In-Ceram Alumina press all-ceramic porcelain systems.

## Material and Methods

In this research, the bending strength of three metal-free porcelain systems with different structures was examined: In Ceram Zirconia (In Ceram Zirconia, Vita, Bad Säckingen, German), In Ceram Alumina (In Ceram Alumina, Vita, Bad Säckingen, German) and Finesse (Finesse, Ceramco, Burlington, NJ, German).

The porcelain samples were prepared by the method recommended in the ISO Standard 6872 (1995). A multiple-point stainless Steel mold having a rectangular cavity of 2 mm x 5 mm x 25 mm was used (Figure 1,2).

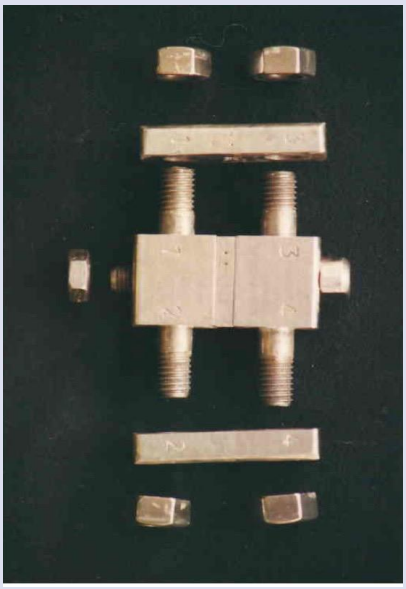


Figure 1.

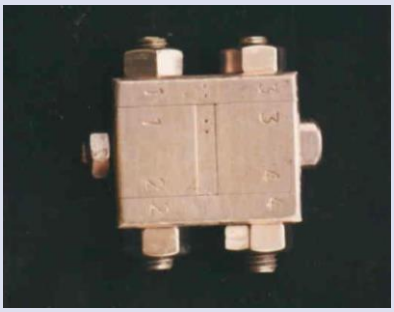


Figure 2.

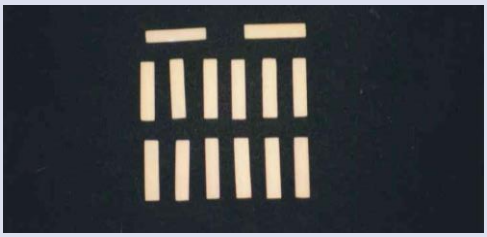


Figure 3.

To prepare the rectangular porcelain sticks obtained with the Finesse porcelain system, these wax molds were created in accordance with the instructions in the prospectus by melting the wax into the necessary wax molds with the heat printing technique. These wax molds formed were mixed in the Revetment mixing machine and pulled into the cylinder plastic casting path and taken to the cuff. These rings were placed first into the preheating oven with a rise of 5°C per minute and heated until the temperature reached 900°C, and the wax removal process was made for one hour. The manchets were taken to the oven without waiting and placed in the manchet anchorage.

According to the manufacturer's instructions, an initial temperature increase of 700°C was provided for 1 hour and a vacuum was activated at 925°C. The oven at 1180°C was kept at that temperature for 7 minutes and then continued to cool itself for 5 hours. All these 14 samples were prepared in the same way (Figure 3).

Following the leveling process, water emery (Nikon/ Japan, No. 400 with No. 600) was applied. It was subjected to abrasion so that its thickness 1.2 ± 0.2 mm, width is 4 ± 0.2 mm, and Length at least 20 mm. Samples were subjected to glazing processes by observing the directions suggested by the manufacturer firm.

Whereas for the porcelain sticks to be made with In Ceram Alumina and Zirconia porcelain systems without metal support, Zirconia porcelain powder for In Ceram Zirconia, Alumina ceramic powder for In Ceram Alumina and were mixed with glass rod in glass beaker according to the suggestions of the manufacturing firm and mixed in the Vita sonic Q device for 5-10 minutes. The mixture made was moved from the glass tube into the plastic tube. The ceramic liquid and ceramic powder the mixture created was applied over the mold made before like wax modeling by using a number 5 sable brush in form of coatings. For each coating, the same process was applied. During these processes, the over-folding sections were subjected to form corrections.

The In Ceram Zirconia and In Ceram Alumina, ceramic samples were moved into the oven manufactured by the firm on the mold and kept there for 6 hours at 120°C with 8.35°C temperature rise per minute. Ceramic samples were kept for 2 hours and at 1120°C they were kept for 2 hours again. Thus, the samples were formed. The distilled water was mixed on the glass, with the glass structure, and applied by using the number 5 sable brush to apply to these structures. The samples were moved into the oven for oven Processing over platinum folio having a thickness of 0.1 mm Temperature of the oven was increased to 1120°C in 30 minutes for In-Ceram Alumina and at this temperature, they were kept there for 4 hours. When the oven temperature reached 400°C degrees, the oven was opened. It was left to cool at room temperature. For In Ceram Zirconia samples, the oven temperature was increased to 1000 °C in half an hour and kept at this temperature for four hours. The oven was opened at 500 °C and left at room temperature to cool down. On the samples taken from the oven, the leveling processes were applied by using diamond burs. This process was applied to each of the 14 samples for In-Ceram Zirconia and In-Ceram Alumina. After, leveling process, water emery (Nikon, No.400 and No. 600, Tokyo, Japan,) was applied and the samples were abraded to have a thickness of 1.2±0.2 mm, a width of 4 ± 0.2 mm and length of at least 20 mm. The samples made were cleaned by keeping them for 10 minutes in the distilled water in the ultrasonic cleaner (Brio Ultrasonics, BR-6 LAB, Barcelona, Spain) and these samples were made ready for measurement Measuring take Flexural Strength: Three-point bending test was used in our study as recommended in ISO standards (1995). The sample bars were loaded in the universal tester (LR 10 K Plus, Lloyd Instruments, Farnham, England) at 0.5 mm/ minute speed. The distance between

the supporting tips was 15 mm and the loading end is centered between the supports.

The load values at fracture of the samples were obtained in kilograms and were converted into Newtons. The flexural strength values for each material were determined using the following equation.

M = 3.W.I/2. b. d2

M = Flexural strength (MPa)

W = Maximum load read before breaking (N)

d = Thickness of sample (mm)

b = Width of sample (mm)

I - Distance between the supports (mm)

Statistical Assessment of Flexural Strength The data obtained in our research were evaluated using the SPSS (Version 15) statistical program, and Mann-Whitney U and Kruskal-Wallis (KW) tests were used in these evaluations.

## Results

After the surface Processing was applied to the samples prepared as Finesse, In Ceram Zirconia, and In Ceram Alumina systems the flexural strength values (Mpa) determined are indicated in Table 1.

When the bending strength values of Finesse, In Ceram Zirconia, and In Ceram Alumina groups (MPa) are compared (Table 2 the difference was found to be statistically significant) ($p<0.05$).

When these values of groups are compared in papers with each other, the difference between In Ceram Zirconia and In Ceram Alumina and between Finesse and In Ceram Alumina groups and the difference between Finesse and In Ceram Zirconia systems were found to be statistically significant ($p<0.05$).

All ceramic porcelain systems found to be the most resistant is the In Ceram Zirconia and in the second row, In Ceram Alumina porcelain system and in the third row, finesse porcelain system concerning durability (Figure 4).

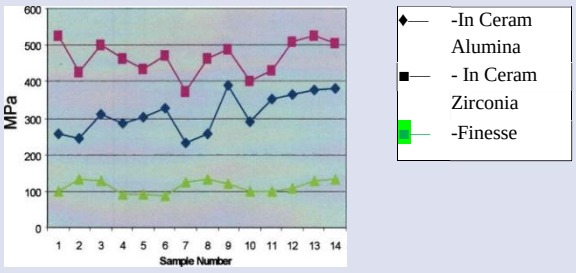



Figure 4. Graphic values of flexural strength values.

## Discussion

There are many debates about the durability of ceramics. There are differences in these discussions. The values obtained in the studies on porcelain are affected by various factors such as thermal values, production speeds, technical changes, production, and thermal defects. The strength values may change depending on the micro cracks on the bottom surface of the rectangular bar obtained for the flexural strength test.[1,9]

The varied data range in the studies is due to differences in sample preparation procedures and test methods. Three-point bending tests, four-point bending tests, ring-on-ring tests, as well as piston-on-three ball tests were used in several different studies.[10]

The transverse resistances of brittle materials are generally evaluated using the bi-axial flexure test or three-point bending test (the one ISO 1995 suggests). Several investigators such as Williamson[11], Cattell[6], and Ohyama[12] have suggested using the three-point bending test because of its reliability, ease, and sensitivity. Thus, we used a three-point bending test in our tests.

Chong et al. compared the bending strengths of In Ceram Zirconia and In Ceram Alumina Systems. They found that the bending strength of In Ceram Zirconia is higher than that of In Ceram Alumina.[10]

Wagner et al. tested In Ceram, Empress, and Procera All Ceram ceramics to compare their biaxial flexural strength. In the study performed with ceramics, the average bending strengths of All Ceram 687 MPa, In Ceram 352 MPa and Empress 134 MPa were found, respectively.[13]

Chong et al. In their study, In Ceram Alumina, they obtained different data between 236.15 and 530 MPa in three- and four-point bending strength tests. In their study with In Ceram Alumina, they reached data between 174.2 and 240 MPa.[10]

Zeng et al. tested the failure stresses in flexural tests of Procera All Ceram, IPS Empress, In-Ceram systems and found that Procera All Ceram had consistently higher fracture stress than the other two materials[14].

Yoshinari et al. Compared the fracture strength of premolar crowns of In-Ceram, Vita-Dur, IPS-Empress and Dicor porcelain systems. Fracture durability of all-ceramic crowns bonded using zinc phosphate cement after applying distilled water Vita In-Ceramda1060N; 770N in Vita Dur porcelain; It is determined as 891N in IPS-Empress porcelain system and 840N in Dicor porcelain.

Strub et al. They were made with 5 different all-ceramic crown systems (Empress, In-Ceram staining technique, Celay feldspathic System, Celay In Ceram and porcelain systems obtained with the Empress coating technique) and evaluated the fracture resistance before and after cyclic preloading used in the artificial jaw. As a result, they found that chewing simulation and thermal cycling significantly reduced the fracture resistance of all tested crown systems.[16]

In dental practice, an ideal restorative structure should have excellent flexural strength. The results of this study show that all-ceramic porcelain systems do not improve the wear of hardness properties. However, long-term clinical data should be examined to understand the properties of these all-ceramic porcelain systems. Flexural strength values should be considered when using all-ceramic porcelain systems for prosthetic restorations in clinical practice.Lin WS et al. They stated in their research that zirconia coated ceramics exhibit greater bending strength than monolithic leucite reinforced and lithium-disilicate ceramics.[17].

Coşkun et al. Finesse, In Ceram Zirconia, and In Ceram Alumina stated that microleakage and marginal adaptations in porcelain systems have no effect on the durability ratio. [18].

In our research, a minimum value of 87.40 Mpa and a maximum value of 132 Mpa for the Finesse porcelain system, a minimum value of 373.10 Mpa and a maximum value of 526.90 Mpa for the In-Ceram Zirconia porcelain system, and a maximum value of 230.00 Mpa for the In-Ceram Alumina porcelain system. The minimum value and the maximum value of 380.80 Mpa were determined (Table 2).

## Conclusions

When the bending strengths of Finesse, In Ceram Zirconia and In Ceram Alumina groups, which are three different all-ceramic systems we used in our research, were compared, the difference was found to be statistically significant ($p<0.05$). The order of bending strength of the porcelain ceramic systems was found as In Ceram Zirconia, In Ceram Alumina and Finesse porcelain ceramic systems, respectively.

## Acknowledgments

VITA Inc. for advice and cooperation. I want to thank Corp.

**Table 1.** Flexure strength of three porcelain systems (MPa)

| | All Ceramic Systems | | |
|---|---|---|---|
| Sample Number | In Ceram Alumina n-14 | In Ceram Zirconia n=14 | Finesse n=14 |
| 1 | 2583 | 526.9 | 98.9 |
| 2 | 243.1 | 426.9 | 132.4 |
| 3 | 311.8 | 501.8 | 127.1 |
| 4 | 287.3 | 4633 | 90.8 |
| 5 | 3023 | 434 | 90.8 |
| 6 | 326.9 | 473.1 | 87.4 |
| 7 | 230 | 373.1 | 124.6 |
| 8 | 2583 | 4633 | 130.5 |
| 9 | 387.5 | 487 | 120.4 |
| 10 | 290.6 | 399.6 | 97.6 |
| 11 | 3503 | 430 | 99.6 |
| 12 | 362.5 | 5103 | 106.5 |
| 13 | 374.6 | 5243 | 129.6 |
| 14 | 380.8 | 502.8 | 132.4 |

**Table 2.** Trans verse strength of three porcelain systems-means, Standard errors and range obviates (Mpa).

| Porcelain Systems | Flexure Strength Mean ± Standart error | Renge (Min-max) |
|---|---|---|
| In-Ceram Alumina n=14 | 304.58 ±13.07 | 230.00 - 380.80 |
| In-Ceram Zirconia n-14 | 465.65 ±12.59 | 373.10-526.90 |
| Finesse | 112.04 ±4.69 | 87.40-132.40 |

KW- 36.10 P<0.05

## References

1. Hondrum SO. A review of the strength properties of dental ceramics. J Prosthet Dent 1992;67: 859-865.
2. Kelly İR. Nishimum I. Campbell SO. Ceramics in dentistry: Historical roots and current perspectives. J Prosthet Dent 1996; 75:18-32.
3. Davis DR. Comparison of fit of two types of all ceramic crowns. J Prosthet Dent 1988; 59:12-16.
4. Suleiman F. Chai J. Jameson LM. Wozniak. WT. A comparison of the marginal fit of In-Ceram. IPS Empress. and Procera crowns. Int J Prosthodont 1997; 10:478-484.
5. Pera P. Gilodi S. Bassi F. Carossa S. İn vitro marginal adaptation of alumina porcelain ceramic crowns. J Prosthet Dent 1994; 72:585-590.
6. Cattell MI. Clarke RL. Lynch. EJR. The biaxial flexural strength and reliability of four dental ceramics – Part II. J Dentistry 1997; 25:409-414.
7. Ban S. Anusavice. KJ. Influence of test method on failure stress of brittle dental materials. J Dent Res 1990; 69:1791-1799.
8. Ritter El. Critique of test methods for lifetime predictions. Dent Mater 1995; 11:147-151.
9. Kelly JR. Perspectives on strength. Dent Mater 1995;11; 103-110.
10. Chong KH. Chai J. Takahashi Y. Wozniak W. Flexural strength of In-Ceram alumina and In-Ceram Zirconia core materials. Int J Prosthodont 2002; 15:183-188.
11. Williamson RT. Kovarik RE. Mitchell RJ. Effects of grinding. polishing and overglazing on the flexure strength of a high-leucite feldspathic porcelain. Int J Prosthodont 1996; 9:30-37.
12. Ohyama T. Yoshinari M. Oda Y. Effects of cyclic loading on the strength of alt ceramic materials. Int J Prosthodont 1993; 12:28-37.

**13.** Wagner WC. Chu TM. Biaxial flexural strength. and indentation fracture toughness of three new dental core ceramics. J Prosthet Dent 1996; 76:140-144.
**14.** Zeng K. Oden A. Rowcliff D. Flexure tests on dental ceramics. Int J Prosthodont 1996; 9:434-439.
**15.** Yoshinari M. Derand T. Fracture strength of all-ceramic crowns. Int J Prosthodont 1994 Jul-Aug;7(4):329-338.
**16.** Strub JR. Beschnidt SM. Fracture strength of 5 different all-ceramic crown systems. Int Prosthodont 1998 Nov-Dec; l l (6):602-609.
**17.** Lin WS. Ercoli C. Feng C. Morton D. The Effect of Core Material Veneering Porcelain. and Fabrication Technique on the Biaxial Flexural Strength and Weibull analysis of Selected Dental Ceramics. J Prosthodont 2012; 21(5):353-362.
**18.** Coşkun A. Yaluğ S. Evaluation of Marginal Adaptation and Microleakage of Different All-Ceramic Porcelain Systems. Cumhuriyet Dental Journal 2022;25(2):131-136.

Cumhuriyet Dental Journal, 26(1): 33-41, 2023
DOI: https://doi.org/10.7126/cumudj.1228295

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 | Available online, ISSN: 1302-5805 e-ISSN: 2146-2852 | Publisher: Sivas Cumhuriyet Üniversitesi

# *Influence of Dental Students' Dietary Habits on Tooth Color*

***Ayse Tugba Erturk-Avunduk[1-a*], Hande Filiz[1-b], Esra Cengiz-Yanardag[1-c]***

*[1] Department of Restorative Dentistry, Faculty of Dentistry, Mersin University, Mersin, Türkiye.*
**Corresponding author*

**Research Article**

*History*

*Received: 02/01/2023*
*Accepted: 15/01/2023*

**ABSTRACT**

***Objectives:*** To determine the influence of dental students' dietary habits on tooth color.
***Materials and Methods:*** A questionnaire consisting of 18 questions was directed to 202 students included in the study. The following exclusion criteria were used for the selection of participants: gingival problems, the presence of excessive abrasion, dental malocclusion, a history of orthodontic or bleaching treatment, caries, and composite fillings on the facial surfaces of the teeth. The color of the upper central incisors and canines of the participants who completed the questionnaire was measured using a clinical spectrophotometer device(Vita Easyshade V). Tooth color assessment was performed by a calibrated operator. The L*, C*, H*, a*, and b* parameters were recorded. Data were subjected to descriptive statistical analysis, Spearman's rho correlation analysis and multivariate testing.
***Results:*** The sample consisted of 202 dentistry students. 96.5% of the participants were between the ages of 18-25 and more than half were female. L*, C*, H*, a*, and b* mean values in canine and incisor teeth did not differ statistically significantly according to age groups($p>0.05$). The mean values of C* and b* in canine teeth and the mean values of all parameters except L* in incisor teeth showed significant differences according to gender($p<0.05$). Staining beverages in the diet had no effect on L*, C*, H*, a*, and b* parameters of the canine and incisor teeth. A negative correlation was found between the frequency of consuming energy drinks and the L* value in the incisor teeth($r=-0.215$; $p=0.016$).
***Conclusions:*** Females have lighter teeth than males. The increase in the amount of consumption of the evaluated staining beverages is one of the factors that cause the tooth colors to become darker and mat.

***Keywords:*** Beverages, Dental Student, Diet, Tooth Color, Spectrophotometer.

# Diş Hekimliği Öğrencilerinin Diyet Alışkanlıklarının Diş Rengine Etkisi

*Süreç*

*Geliş: 02/01/2023*
*Kabul: 15/01/2023*

**ÖZ**

***Amaç:*** Bu çalışmanın amacı, diş hekimliği öğrencilerinin diyet alışkanlıklarının diş rengine olan etkisini belirlemektir.
***Gereç ve Yöntemler:*** Çalışmaya dahil edilen 202 öğrenciye 18 sorudan oluşan bir anket yönlendirildi. Katılımcıların seçiminde kullanılan dışlama kriterleri şu şekildedir: dişeti problemleri, aşırı aşınma varlığı, diş maloklüzyonu, ortodontik veya beyazlatma tedavisi öyküsü, dişlerin bukkal yüzeylerinde çürük ve kompozit restorasyon olması. Anketi tamamlayan katılımcıların üst santral ve kanin dişlerinin rengi klinik bir spektrofotometre cihazı (Vita Easyshade V) kullanılarak ölçüldü. Diş rengi değerlendirmesi, kalibre edilmiş bir operatör tarafından yapıldı. L*, C*, H*, a* ve b* parametreleri kaydedildi. Veriler tanımlayıcı istatistiksel analize, Spearman's rho korelasyon analizine ve çok değişkenli testlere tabi tutuldu.
***Bulgular:*** Örneklemi 202 diş hekimliği öğrencisi oluşturdu. Katılımcıların %96,5'i 18-25 yaşları arasındaydı ve yarısından fazlası kadındı. Kanin ve santral dişlerde L*, C*, H*, a* ve b* ortalama değerleri yaş gruplarına göre istatistiksel olarak anlamlı farklılık göstermedi ($p>0,05$). Kanin dişlerinde C* ve b* ortalama değerleri ile santral dişlerde L* dışındaki tüm parametrelerin ortalama değerleri cinsiyete göre anlamlı farklılık gösterdi ($p<0,05$). Diyetteki renklendirici içeceklerin kanin ve santral dişlerin L*, C*, H*, a* ve b* parametrelerinin ortalama değerlerine etkisi olmadı. Ancak santral dişte, enerji içeceği içme sıklığı ile L* değeri arasında negatif yönlü zayıf bir ilişki tespit edilmiştir ($r=-0,215$; $p=0,016$).
***Sonuçlar:*** Kadınların diş renkleri erkeklerden daha açıktır. Değerlendirilen boyayıcı içeceklerin tüketim miktarının artması diş renklerinin koyulaşmasına ve matlaşmasına neden olan faktörlerden biridir.



a aysetugba11@gmail.com https://orcid.org/0000-0002-7879-8150
b hande_filizz@hotmail.com https://orcid.org/0000-0002-8100-6871
c dtesracengiz@yahoo.com https://orcid.org/0000-0002-2651-2755

*How to Cite:* Erturk-Avunduk AT, Filiz H, Cengiz-Yanardag E.(2023) Influence of Dental Students' Dietary Habits on Tooth Color, Cumhuriyet Dental Journal, 26(1):33-41.

## Introduction

Nowadays, individuals want to have a perfect smile as well as having a good oral-dental health.[1] The appearance of the teeth should be beautiful as well as proportional to each other and arranged in harmony with the gingiva, lips, and face in order to provide smile esthetics in dentistry.[2]

The structure of the tooth consists of tissues like enamel, dentin and pulp. The light scattering and absorption properties of enamel and dentin tissues are effective factors in determining the actual tooth color.[1, 3] Some deposits on tooth surfaces and structural changes arising from tissues can lead to changes in tooth color. The etiology of discoloration is multifactorial and tooth discoloration can be internal or external.[4] Mainly internal discolorations may occur due to amelogenesis and dentinogenesis imperfecta, enamel hypoplasia, tetracycline and fluorosis discolorations, root resorption, and aging.[5] Poor oral hygiene, metal salts, smoking, dietary beverages (tea, coffee, red wine, cola, etc.) are the leading causes of external coloration.[6]

Color is a complex phenomenon and there are many factors (human eye, light conditions, light scattering, opacity and translucency) that affect color perception.[7] For this reason, besides the visual method, instrumental techniques are also used to minimize these factors in the color selection of teeth and dental restorations. Since visual color detection is a subjective method, instrumental techniques eliminate this situation. For this purpose, spectrophotometers, colorimeters and digital image analyzes are widely used in dental practice. Spectrophotometers are the most commonly used instruments among instrumental techniques and measure the amount of light energy reflected back from an object in the visible spectrum range.[8] Compared to conventional methods or evaluations performed with the human eye, spectrophotometers have been reported to have increased accuracy and provide more objective matching.[9]

The CIELAB (Commission International de l'Eclairage) color system is one of the most widely used color measurement systems in dentistry.[10] In the CIELAB system, color is defined with 3 coordinates, L*, a* and b*.[11] L* creates the lightness-darkness coordinates of the color between white (+) - black (-). This parameter is on the vertical axis and is proportional to the tone (value). One of the color components, a*, is between red (+) – green (-) on the horizontal axis; b* represents the chroma coordinates between yellow (+) - blue (-) on the horizontal axis.[12] In the CIEDE2000 color system, L; lightness, C; color intensity (chroma) and H; represents hue (hue).[13] This system is widely used by researchers to evaluate the color changes of different materials.[14] The CIEDE2000 color system was presented as a better alternative to the CIELAB system defined in 2001. The CIEDE2000 color system corrects inconsistencies from the CIELAB system. It also provides a better correlation between the perceived and measured color change amount.[15] Thus, it better reflects the perceptibility and acceptability threshold values for color differences compared to the CIELAB system.[16]

There are many studies in the literature about the oral-dental health levels and dietary habits of dentistry students. However, the number of studies examining the effect of diet habits of dental students on natural tooth color is limited.[17-20] The aim of the present study is to evaluate the effects of demographic characteristics (age and gender) and dietary habits (consumption of tea, coffee, acidic, and staining drinks) on the tooth color of dentistry students. The null hypotheses of the study are as follows: [a] Age and gender would not affect tooth color, [b] Dietary staining and acidic beverages would not affect tooth color.

## Materials and Methods

The present cross-sectional study was conducted from November to December 2022 using a questionnaire. The study protocol was approved by the Mersin University ethics committee (number 2022/708). It was conducted in accordance with the latest guidelines of the Declaration of Helsinki. The study was conducted following the STROBE guidelines.[21]

### *Participants*

The sample size was calculated by using the G*Power (V. 3. 1. 9. 6) package program. With 95% confidence (1-α), 95% test power (1-β), f=0.40 effect size, the minimum number of cases to be included in the study was determined as 131 (125/0.955). Individuals in the current epidemiological study were selected among dentistry students who accepted to participate in the study and were studying at Mersin University Faculty of Dentistry. Intraoral examinations of the participants were performed in Mersin University Faculty of Dentistry, Department of Restorative Dentistry. Volunteers who agreed to participate in the study were given a questionnaire prepared by the researchers and asked to fill in. Individuals who did not agree to fill out the questionnaire were not included in the study. Reminder announcements were made to the students in order to increase the participant rate and to minimize the risk of bias.

The teeth of the volunteers to be included in the study were screened according to the following inclusion criteria: Being over 18 years old and having right or left maxillary central and canine teeth (chosen because of easy to see )in the mouth. Exclusion criteria were as follows: Presence of fixed orthodontic appliances, pregnancy, previous professional dental prophylaxis performed in less than 6 months, upper central/canine teeth with restoration, endodontic treatment or presence of caries.

### *Questionnaire*

The questions used in the present work were modified from previous questionnaires validated by Nalbant *et al.*[18] and Calzada *et al.*[22] and directed to the students. A pilot test on 20 dentistry students was conducted and subject to minor adjustments on the questionnaire. As a result of the

research, it was planned to see the effect of the age, gender and dietary habits of the person on the color of the teeth.

### *Color measurement*

In the present study, the measurement of color values in teeth was made with a clinical spectrophotometer device (VITA EasyShade V, Vita Zahnfabrik, Germany). The device has a 1.5 x 2 inch touch screen on its own. With the help of the automatic calibration plate, the device was calibrated before each measuring. VITA EasyShade V can be used in any lighting conditions, unaffected by halogen light or ambient light. It measures with both CIELAB and CIEDE2000 color systems and the device has the feature of archiving the measurements.

Tooth color assessment was performed by a calibrated operator (H. F.). Measurements were performed between 10.00 and 14.00, which is the time zone when daylight is most active. During color measurements, the participants were asked to hold their heads steady, lean on the unit headrest and open their mouths slightly. In order to eliminate tissue reflection due to transparency in the incisal (cutting edge) areas of the teeth, since the resting tongue on the upper jaw anterior palate area may cause erroneous measurements; the tongue was kept in the resting position. The reflector (unit light) was kept off during the measurements. The measuring tip of the spectrophoto meter was placed as perpendicular to the facial surface of the tooth as possible (Figure 1). Color measurements started from the central teeth and continued with the canine teeth. To ensure standardization, measurements were taken from the middle third of the teeth facing the lip. The data obtained after the measurements were transferred to the computer for analysis.

Figure 1. Color measurement of teeth

### *Statistical analysis*

Statistical analyzes were performed using the Statistical Package for the Social Sciences (Version 25.0, SPSS Inc., Chicago, IL, USA). Analysis of demographic data was done by descriptive statistical analysis. Multivariate analysis was used to compare the L*, C*, H*, a* and b* values obtained from the upper central (incisors) and canine teeth, and Spearman's rho correlation analysis was used to determine the relationship between them. Analysis results were presented as mean and standard deviation. Statistical significance level was taken as $p<0.05$.

## Results

The questionnaire was directed to 250 students, of whom 202 completed the questionnaire and met the inclusion criteria (81% participation rate). The demographic distributions (n, %) of data are summarized in Table 1. 96.5% of the participants were between the ages of 18-25 and more than half were women. The proportion of those who consumed tea and coffee twice a day or more in their diet was close to each other (38.6% and 37.3%, respectively). The rate of those who never used acidic beverages was 10%. 76.7% of the participants rarely used staining beverages (juice, wine, etc.) in their diet.

Table 2 shows the comparisons between color parameters by age groups for each tooth measured (upper central and canine teeth). L*, C*, H*, a* and b* mean values in canine and central teeth did not differ statistically significantly according to age groups ($p>0.05$). However, it was observed that the lightness (L*) of the color parameters of the teeth increased with advancing age.

Table 3 summarizes the comparisons between color parameters by sex for each tooth (central and canine teeth). C* and b* mean values of canine teeth were found to differ significantly by gender ($p<0.001$). The mean values of all parameters of central teeth except L* differed significantly according to gender ($p<0.05$).

The mean and standard deviation values of the color parameters according to the dietary habits of the central and canine teeth are shown in Table 4 and Table 5, respectively. It was observed that dietary staining beverages (tea, coffee, acidic and colored drinks) had no effect on the mean values of L*, C*, H*, a* and b* parameters of canine and central teeth ($p>0.05$).

There was no statistically significant correlation between age and color parameters in canine and central teeth ($p>0.05$). The results of the correlation analysis between the color parameters according to the frequency of consumption of dietary beverages are summarized in Table 6. A weak negative correlation was found between the frequency of consuming energy drinks and the L* value only in the central tooth ($r=-0.215$; $p=0.016$). Other relationships were not statistically significant ($p>0.05$).

## Discussion

Color changes can be observed in teeth that are exposed to foods and beverages taken intermittently with the diet, and to chemical agents that are constantly absorbed from adherent debris or released as a result of bacterial decomposition of the debris.[19] In this context, demographic characteristics of dentistry students such as age and gender, and the effect of dietary staining agents on tooth color were investigated in the current study.

Dentistry students represent the sample of the current study. Because they can improve and change their attitudes/behaviors toward their oral health and dietary habits through dental education. On the other hand, follow-up is more convenient and the administration and application of the questionnaire are easy. The

questionnaire used in the present study was primarily conducted as a pilot test and following reminder announcements were made to increase participation in order to limit bias.[23] An optimum response rate of 70% to 80% is preferred to minimize the risk of bias.[24] In studies conducted on dental students, this rate varies from 68%[25] to 89%[26]. The participation rate in the present study is 81% and this rate can be considered as high.

Visual and instrumental techniques can be used to evaluate color changes in teeth and dental materials.[27] It has been stated that visual color assessment is unreliable due to interobserver inconsistencies in color perceptions.[28] Therefore, instrumental techniques are widely preferred to provide an objective interpretation in the determination of color changes. At the same time, instrumental techniques are considered advantageous over visual methods in terms of analyzing the physical properties of color, reproducibility of measurements, and giving quantifiable results.[16] Choi *et al.*[29] concluded that digital analysis of tooth color is more accurate and reproducible than a visual assessment. The CIEDE2000 color system also includes some color parameters based on the CIELAB system. These include the lightness darkness (L—lightness), saturation (C—chroma) and hue (H—hue) of the color and their weighting functions, an interactive parameter (ΔR) between saturation and hue difference for blue colors. It also includes the a* parameter to improve the performance of gray colors. Researchers reported that the variable factors in the CIELAB color system were not evaluated equally, and the CIEDE2000 color system was more compatible in determining acceptability and perceptibility closest to the range of values that the eye could perceive.[30] The VITA Easyshade V used in the current study is a clinical spectrophotometer used for tooth color matching.

Some studies have reported that light conditions can affect the assessment of tooth color, which can be controlled if a standard environment has already been established.[1,31] Therefore, in the present study, measurements were made in a standard time zone. In our study, color measurements were performed from the middle thirds of the upper central and canine teeth to ensure standardization. A previous study has described the middle third of the tooth as the region that best represents color.[1] It has been stated that the incisal region is usually translucent and affects the background of the tooth, while the color of the cervical area is changed by the light scattered from the gingiva.[27]

Since our sample consisted of students studying in the faculties of dentistry, 96.5% of the participants were between the ages of 18-25 and it was seen that there was no statistically significant difference between color parameters according to age groups. This finding contradicts with the results of Demirel & Tunçdemir.[32] Researchers reported significant differences in all L*, a*, and b* parameters for age subgroups (≤35, 35–55, and ≥55). The fact that the participants in the current study were very young may have caused the lack of difference in the present study. On the other hand, a statistically insignificant increase in the lightness parameter was observed in participants with older age of canine teeth.

Gender is another factor that is significantly associated with tooth color. In a certain age group, the teeth color values of males in the population were found to be darker than females.[33] In the present study, it was observed that the mean values of C* and b* values of canine teeth and mean values of all parameters except L* of central teeth showed significant differences according to gender. This was similar to a previous study that reported no significant difference in the L* parameter for the sex subgroup.[32] However, in the present study, although there was no statistically significant difference, canine teeth were found to be brighter in males. It was also evident that the white tone of the males' teeth was similar to that of the females, but appeared darker because the yellow and red tones were stronger. Hasegawa *et al.*[34] reported that with advancing age, the lightness of the teeth tended to decrease and the yellowness increased, but the difference between male and female could not be distinguished. Considering these findings, our first null hypothesis, which was stated as "age and gender will not affect tooth color", was partially rejected.

Understanding the etiology of tooth discoloration, which is caused by various factors, facilitates the correct diagnosis and affects the treatment options that the dentist will apply to patients.[35] Tooth discoloration occurs due to external factors (tea, coffee, red wine, cigarettes, cola, metal salts, and poor oral hygiene) and internal factors (due to the change in the structural composition or thickness of dental hard tissues). It has been reported that commonly consumed beverages such as tea, coffee, red wine, fruit juice and cola cause significant discoloration in teeth as well as in tooth-colored restorative materials.[36] In the present study, it was observed that the staining beverages did not cause a significant difference in the color parameters of the central and canine teeth. Therefore, the second hypothesis of the study was accepted. The reason for this finding can be concluded that the study sample consisted of dentistry students and they had sufficient knowledge about oral-dental health and caries prophylaxis. On the other hand, it was observed that the increase in the consumption of staining beverages evaluated in the study was one of the factors that caused the darkening and dulling of tooth colors. It was determined that the L* parameter of the central and canine teeth increased in the participants who consumed colored beverages (fruit juice, wine, etc.) 2 or more times a day, that is, the teeth were darker. There are studies evaluating the effect of colored beverages in the diet on tooth color according to the frequency of consumption of individuals.[19, 37] A previous study investigating the effect of food and beverages consumed on primary and permanent tooth color reported that tooth enamel color changed.[19] In accordance with the present study, the researchers observed that the tooth color was darker in individuals with a higher frequency of consumption of staining beverages.

When the correlation analysis findings of our study were examined, it was seen that there was no significant relationship between age and color parameters, but there was a weak negative correlation between the frequency of consumption of energy drinks taken with diet and the L* parameter. As stated before, the age range of the population constituting our study sample is very close to each other and 96.5% of the participants are between the ages of 18-25, which may have caused this result. A previous study in Japanese population investigated the relationship between the age and the color of central teeth over a wide age range (13-84 years). Researchers have reported that there is a negative correlation between age and the L* parameter, and a positive correlation with the b* and a* parameters.[34] There are studies that show differences in the external appearance of teeth with increasing age.[38, 39] Aged dentin (sclerotic dentin) is dark and mineralized. Its density is high and its lightness is decreased. In advanced age, the color of dentin undergoes a change and exhibits a transition from red-yellow to yellow. However, because of wear, the glossy enamel thickness to cover the dentinal redness is reduced, and the color of old teeth appears redder than that of young ones. [34]

The present study has several limitations. First, the measurements were made only with the spectrophotometer device. Using and comparing different color measurement methods (calorimeter, digital camera, etc.) may produce different results. In addition, increasing the number of samples and including older age groups will increase the accuracy of the study and will give more meaningful results for these statistical analyses. In the future, it may be appropriate to include students from different faculties in the sampling or to conduct more research on different populations.

**Table 1.** The distribution of the demographic data

| | n | % |
|---|---|---|
| **Age** | | |
| 18-25 | 195 | 96.5 |
| 25-30 | 7 | 3.5 |
| Gender | | |
| Female | 102 | 50.5 |
| Male | 100 | 49.5 |
| **The frequency of smoking** | | |
| I never consume | 114 | 56.4 |
| Rarely | 40 | 19.8 |
| Once in a day | 46 | 22.8 |
| Twice or more in a day | 2 | 1.0 |
| **The frequency of consuming tea** | | |
| I never consume | 11 | 5.4 |
| Rarely | 39 | 19.3 |
| Once in a day | 74 | 36.6 |
| Twice or more in a day | 78 | 38.6 |
| **The frequency of consuming coffee** | | |
| I never consume | 4 | 2.0 |
| Rarely | 45 | 22.4 |
| Once in a day | 77 | 38.3 |
| Twice or more in a day | 75 | 37.3 |
| **The frequency of consuming acidic beverages** | | |
| I never consume | 20 | 10.0 |
| Rarely | 123 | 61.2 |
| Once in a day | 43 | 21.4 |
| Twice or more in a day | 15 | 7.5 |
| **The frequency of consuming colored beverages (wine, juice etc.)** | | |
| I never consume | 20 | 9.9 |
| Rarely | 155 | 76.7 |
| Once in a day | 26 | 12.9 |
| Twice or more in a day | 1 | 0.5 |
| **The frequency of consuming energy drinks** | | |
| I never consume | 54 | 26.7 |
| Rarely | 117 | 57.9 |
| Once in a day | 25 | 12.4 |
| Twice or more in a day | 6 | 3.0 |

**Table 2.** Comparisons by age groups for each tooth

| | Central Incisor | | | Canine | | |
|---|---|---|---|---|---|---|
| | **18-25** | **25-30** | **p** | **18-25** | **25-30** | **p** |
| **L*** | 77.3 ± 3.8 | 77.8 ± 3.7 | 0.712 | 71 ± 3.4 | 72.4 ± 2.3 | 0.261 |
| **C*** | 18.3 ± 4.2 | 17.7 ± 2.5 | 0.743 | 24.6 ± 3.2 | 25.5 ± 3.6 | 0.447 |
| **H*** | 93.4 ± 5.9 | 93.1 ± 2.6 | 0.894 | 87.4 ± 10.7 | 86.3 ± 0.8 | 0.788 |
| **a*** | -0.7 ± 1.1 | -0.9 ± 0.7 | 0.711 | 1.5 ± 0.5 | 1.6 ± 0.4 | 0.674 |
| **b*** | 17.9 ± 3.3 | 17.7 ± 2.5 | 0.855 | 24.4 ± 2.9 | 25.5 ± 3.6 | 0.369 |

**p<0.05 is significant. p values are based on a Multivariate analysis test.*

**Table 3.** Comparisons by gender for each tooth

| | Central Incisor | | | Canine | | |
|---|---|---|---|---|---|---|
| | **Female** | **Male** | **p** | **Female** | **Male** | **p** |
| **L*** | 77.8 ± 3.4 | 76.8 ± 4 | 0.052 | 70.8 ± 3.4 | 71.2 ± 3.4 | 0.455 |
| **C*** | 17.2 ± 3.3 | 19.3 ± 4.7 | <0.001* | 23.8 ± 2.8 | 25.5 ± 3.4 | <0.001* |
| **H*** | 94.3 ± 4.1 | 92.4 ± 7.0 | 0.017* | 88.4 ± 14.7 | 86.3 ± 1.2 | 0.169 |
| **a*** | -1.0 ± 1.0 | -0.4 ± 1.1 | <0.001* | 1.5 ± 0.5 | 1.6 ± 0.5 | 0.083 |
| **b*** | 17 ± 2.8 | 18.9 ± 3.6 | <0.001* | 23.8 ± 2.8 | 25.2 ± 2.9 | <0.001* |

*p<0.05 is significant. p values are based on a Multivariate analysis test.

**Table 4:** Means± standard deviations of color parameters of central incisor teeth according to dietary habit

| | | Tea | | Coffee | | Acidic beverages | | Colored beverages | | Energy drink | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Mean± sd** | **p** | **Mean± sd** | **p** | **Mean± sd** | **p** | **Mean± sd** | **P** | **Mean± sd** | **P** |
| L* | I never consume | 78.5±2.7 | 0.726 | 75.3 ± 4.3 | 0.732 | 77.8 ± 4.4 | 0.615 | 77.1 ± 4 | 0.490 | 76.7 ± 3.4 | 0.072 |
| | Rarely | 77.2±4.9 | | 77.5 ± 3.5 | | 77.4 ± 3.6 | | 77.3 ± 3.8 | | 77.9 ± 3.8 | |
| | Once in a day | 77.1±3.4 | | 77.3 ± 3.7 | | 77.4 ± 3.8 | | 77.2 ± 3.4 | | 76.1 ± 3.9 | |
| | Twice or more in a day | 77.4±3.5 | | 77.3 ± 3.9 | | 76.2 ± 3.4 | | 83.1 ± 0 | | 76.8 ± 3.8 | |
| C* | I never consume | 17.9±2.6 | 0.506 | 22.1 ± 7.5 | 0.173 | 17.3 ± 2.6 | 0.638 | 17.7 ± 2.8 | 0.614 | 17.7 ± 3.1 | 0.371 |
| | Rarely | 19.1±6.3 | | 17.6 ± 2.8 | | 18.5 ± 4.7 | | 18.4 ± 4.4 | | 18.6 ± 4.6 | |
| | Once in a day | 17.9±3.9 | | 18.6 ± 3.9 | | 17.9 ± 3.4 | | 17.8 ± 3.5 | | 18.4 ± 4.3 | |
| | Twice or more in a day | 18.2±3.2 | | 18.2 ± 4.9 | | 18.4 ± 3.5 | | 22.5 ± 0 | | 16.1 ± 2.7 | |
| H* | I never consume | 93.2±3.7 | 0.448 | 91.1 ± 5.5 | 0.873 | 93.3 ± 4.6 | 0.901 | 92.7 ± 2.9 | 0.824 | 93 ± 3.7 | 0.635 |
| | Rarely | 94.7±10.1 | | 93.6 ± 3.8 | | 93.6 ± 6.6 | | 93.5 ± 6.2 | | 93.6 ± 6.7 | |
| | Once in a day | 93.2±4.4 | | 93.3 ± 7.8 | | 93 ± 3.9 | | 93.3 ± 4.6 | | 92.4 ± 4.3 | |
| | Twice or more in a day | 92.9± 3.8 | | 93.3 ± 4.2 | | 92.7 ± 4.7 | | 88.9 ± 0 | | 95.2 ± 6 | |
| a* | I never consume | -0.7 ± 0.8 | 0.999 | -0.2 ± 1.6 | 0.250 | -0.7 ± 1.1 | 0.969 | -0.7 ± 0.9 | 0.771 | -0.7 ± 1 | 0.649 |
| | Rarely | -0.7 ± 1.3 | | -0.9 ± 1 | | -0.7 ± 1.1 | | -0.7 ± 1.1 | | -0.7 ± 1.1 | |
| | Once in a day | -0.7 ± 1.1 | | -0.5 ± 1.1 | | -0.7 ± 1.1 | | -0.8 ± 1.2 | | -0.6 ± 1.3 | |
| | Twice or more in a day | -0.7 ± 1.1 | | -0.8 ± 1.2 | | -0.6 ± 1.2 | | 0.4 ± 0 | | -1.2 ± 1.3 | |
| b* | I never consume | 18 ± 2.5 | 0.708 | 22 ± 7.6 | 0.051 | 17.3 ± 2.7 | 0.743 | 17.6 ± 2.8 | 0.503 | 17.7 ± 3.2 | 0.377 |
| | Rarely | 18.2 ± 3.7 | | 17.5 ± 2.9 | | 18 ± 3.4 | | 18 ± 3.4 | | 18.2 ± 3.6 | |
| | Once in a day | 17.6 ± 3.3 | | 18.3 ± 3.3 | | 17.8 ± 3.3 | | 17.6 ± 3.4 | | 17.7 ± 2.3 | |
| | Twice or more in a day | 18.1 ± 3.3 | | 17.7 ± 3.1 | | 18.3 ± 3.6 | | 22.5 ± 0 | | 16 ± 2.8 | |

p<0.05 stands for statistically significance. p values are based on a Multivariate analysis test.

**Table 5:** Means± standard deviations of color parameters of canine teeth according to dietary habits

| | | Tea | | Coffee | | Acidic beverages | | Colored beverages | | Energy drinks | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean± sd | P | Mean± sd | P | Mean± sd | p | Mean± sd | P | Mean± sd | P |
| L* | I never consume | 71 ± 2.7 | 0.701 | 69 ± 4 | 0.234 | 71.4 ± 2.3 | 0.813 | 71.6 ± 3.6 | 0.677 | 71.3 ± 3.4 | 0.059 |
| | Rarely | 71.5 ± 3.8 | | 71.4 ± 3.3 | | 70.9 ± 3.6 | | 71 ± 3.3 | | 71.2 ± 3.1 | |
| | Once in a day | 71 ± 3 | | 71.4 ± 3.1 | | 71.3 ± 3 | | 70.8 ± 3.7 | | 69.3 ± 4.2 | |
| | Twice or more in a day | 70.8 ± 3.5 | | 70.6 ± 3.5 | | 70.5 ± 3.8 | | 74.1 ± 0 | | 71.1 ± 2.7 | |
| C* | I never consume | 25.1 ± 3.5 | 0.566 | 26.6 ± 3.8 | 0.651 | 24.4 ± 2.5 | 0.729 | 24.9 ± 3.1 | 0.885 | 25.1 ± 4.2 | 0.411 |
| | Rarely | 25.1 ± 4.2 | | 24.6 ± 3.8 | | 24.5 ± 3.1 | | 24.5 ± 3 | | 24.6 ± 2.8 | |
| | Once in a day | 24.3 ± 3 | | 24.7 ± 3 | | 24.8 ± 3.8 | | 24.9 ± 4.4 | | 24.1 ± 2.8 | |
| | Twice or more in a day | 24.7 ± 2.8 | | 24.5 ± 3 | | 25.5 ± 3.1 | | 25.9 ± 0 | | 23.5 ± 1.9 | |
| H* | I never consume | 86.8 ± 0.6 | 0.932 | 85.4 ± 1.3 | 0.843 | 86.3 ± 0.8 | 0.738 | 86.3 ± 1.4 | 0.877 | 87.6 ± 9.2 | 0.888 |
| | Rarely | 86.6 ± 1.5 | | 86.5 ± 1.7 | | 88 ± 13.4 | | 87.7 ± 12 | | 87.6 ± 12.3 | |
| | Once in a day | 87.2 ± 7.8 | | 87.2 ± 7.7 | | 86.4 ± 1.3 | | 86.2 ± 1.5 | | 86.1 ± 1.3 | |
| | Twice or more in a day | 87.9 ± 15.1 | | 88.1± 15.4 | | 86 ± 1.5 | | 87.3 ± 0 | | 85.6 ± 1.1 | |
| a* | I never consume | 1.4 ± 0.4 | 0.289 | 2 ± 0.5 | 0.281 | 1.6 ± 0.3 | 0.872 | 1.6 ± 0.5 | 0.914 | 1.6 ± 0.6 | 0.461 |
| | Rarely | 1.4 ± 0.6 | | 1.5 ± 0.6 | | 1.5 ± 0.5 | | 1.5 ± 0.5 | | 1.5 ± 0.5 | |
| | Once in a day | 1.5 ± 0.5 | | 1.5 ± 0.4 | | 1.5 ± 0.5 | | 1.5 ± 0.5 | | 1.7 ± 0.5 | |
| | Twice or more in a day | 1.6 ± 0.5 | | 1.6 ± 0.5 | | 1.6 ± 0.5 | | 1.2 ± 0 | | 1.6 ± 0.4 | |
| b* | I never consume | 25.1 ± 3.5 | 0.747 | 26.6 ± 3.8 | 0.401 | 24.3 ± 2.5 | 0.658 | 24.8 ± 3.1 | 0.879 | 24.7 ± 3.5 | 0.602 |
| | Rarely | 24.6 ± 3.3 | | 24.2 ± 2.8 | | 24.5 ± 3.1 | | 24.5 ± 2.9 | | 24.5 ± 2.7 | |
| | Once in a day | 24.2 ± 2.8 | | 24.7 ± 2.8 | | 24.4 ± 2.5 | | 24.2 ± 3 | | 24 ± 2.8 | |
| | Twice or more in a day | 24.6 ± 2.8 | | 24.5 ± 3 | | 25.4 ± 3.1 | | 25.9 ± 0 | | 23.4 ± 1.9 | |

p<0.05 stands for statistically significance. P values are based on a Multivariate analysis test.

**Table 6**. The findings of correlation analysis.

| Tooth | | | L* | C* | H* | a* | b* |
|---|---|---|---|---|---|---|---|
| Canine | The frequency of consuming tea | r | -0.060 | -0.012 | -0.131 | 0.107 | -0.008 |
| | | p | 0.397 | 0.869 | 0.064 | 0.128 | 0.914 |
| | The frequency of consuming coffee | r | -0.073 | -0.024 | -0.032 | 0.037 | -0.009 |
| | | p | 0.304 | 0.733 | 0.649 | 0.603 | 0.903 |
| | The frequency of consuming acidic beverages | r | -0.010 | 0.061 | 0.000 | -0.009 | 0.043 |
| | | p | 0.891 | 0.387 | 0.996 | 0.904 | 0.548 |
| | The frequency of consuming colored beverages (wine,juice etc) | r | -0.027 | -0.004 | -0.009 | -0.033 | -0.014 |
| | | p | 0.698 | 0.953 | 0.894 | 0.637 | 0.843 |
| | The frequency of consuming energy drink | r | -0.083 | 0.024 | 0.029 | -0.009 | 0.011 |
| | | p | 0.360 | 0.788 | 0.748 | 0.924 | 0.905 |
| Central Incisor | The frequency of consuming tea | r | -0.071 | 0.005 | -0.073 | 0.033 | 0.017 |
| | | p | 0.318 | 0.945 | 0.302 | 0.636 | 0.807 |
| | The frequency of consuming coffee | r | -0.019 | -0.018 | 0.022 | -0.028 | -0.024 |
| | | p | 0.785 | 0.797 | 0.757 | 0.695 | 0.737 |
| | The frequency of consuming acidic beverages | r | -0.070 | 0.018 | -0.033 | 0.017 | 0.024 |
| | | p | 0.322 | 0.800 | 0.643 | 0.809 | 0.734 |
| | The frequency of consuming colored beverages (wine,juice etc) | r | 0.020 | 0.017 | -0.002 | -0.006 | 0.011 |
| | | p | 0.773 | 0.816 | 0.980 | 0.930 | 0.874 |
| | The frequency of consuming energy drink | r | -.215* | 0.066 | -0.066 | 0.117 | 0.083 |
| | | p | 0.016 | 0.463 | 0.462 | 0.194 | 0.356 |

r: Spearman's rho correlation coefficient. p<0.05 stands for statistical significance.

## Conclusions

Within the limitations of the present study, the results can be summarized as follows: Since the ages of the participants included in the study were very close to each other, the age parameter had no effect on tooth color. The central incisors in females and canines in males were more lightness color. The increase in the consumption amount of the evaluated staining beverages is one of the factors that cause the darkening and dulling of the tooth colors. When staining beverages (juice, wine, etc.) were consumed two times or more a day, the measured teeth became darker.

## Acknowledgements

The authors thank Naci Murat for his kind support during the statistical analysis.

## Author contributions

**Conceptualization:** Ayse Tugba Erturk-Avunduk, Esra Cengiz-Yanardag; **Methodology:** Ayse Tugba Erturk-Avunduk, Esra Cengiz-Yanardag; **Software:** Ayse Tugba Erturk-Avunduk, Esra Cengiz-Yanardag; **Validation:** Ayse Tugba Erturk-Avunduk, Esra Cengiz-Yanardag,
**Investigation:** Ayse Tugba Erturk-Avunduk, Hande Filiz; **Resources:** Ayse Tugba Erturk-Avunduk, Hande Filiz, Esra Cengiz-Yanardag; **Data curation:** Ayse Tugba Erturk-Avunduk, Esra Cengiz-Yanardag, Hande Filiz; **Writing–original draft preparation:** Ayse Tugba Erturk-Avunduk; **Writing–review and editing:** Ayse Tugba Erturk-Avunduk, Esra Cengiz-Yanardag; **Visualization:** Ayse Tugba Erturk-Avunduk, Esra Cengiz-Yanardag.

## Declaration of Interests

The authors declare that they have no conflict of interest.

This study was presented as a poster presentation at the Society of Restorative Dentistry (RDD) Winter Symposium (17-18 December 2022, Adana, Türkiye).

## References


1. Joiner A. Tooth colour: a review of the literature. J Dent 2004;32:3-12.
2. Terry DA, et al. Anatomical form defines color: function, form, and aesthetics. Pract Proced Aesthet Dent 2002;14:59-78
3. Ten Bosch J, Coops J. Tooth color and reflectance as related to light scattering and enamel hardness. J Dent Res 1995;74:374-380.
4. Bagheri R, Burrow M, Tyas M. Influence of food-simulating solutions and surface finish on susceptibility to staining of aesthetic restorative materials. J Dent 2005;33:389-398.
5. Watts A, Addy M. Tooth discolouration and staining: a review of the literature. Br Dent J 2001;190:309-316.
6. Ashcroft AT, et al. Evaluation of a new silica whitening toothpaste containing blue covarine on the colour of anterior restoration materials in vitro. J Dent 2008;36:26-31.
7. Ilie N, Hickel R. Silorane-based dental composite: behavior and abilities. Dent Mater J 2006;25:445-454.
8. Al-Boni R, Raja OM. Microleakage evaluation of silorane based composite versus methacrylate based composite. J Conserv Dent 2010;13:152-155.
9. Wei Y-j, et al. Hygroscopic dimensional changes of self-adhering and new resin-matrix composites during water sorption/desorption cycles. Dent Mater 2011;27:259-66.
10. Mourouzis P, Koulaouzidou EA, Helvatjoglu-Antoniades M. Effect of in-office bleaching agents on physical properties of dental composite resins. Quintessence Int 2013;44:295-302.
11. Sengez G, Dörter C. Estetik diş hekimliğinde renk seçimi. Selcuk Dental Journal 2019;6:213-220.
12. Önal B, Recen D, Türkün L. Restoratif diş hekimliğinde renk seçimi. Turkiye Klinikleri J Restor Dent-Special Topics 2015;1:21-27.
13. Luo MR, Cui G, Rigg B. The development of the CIE 2000 colour-difference formula: CIEDE2000. Color Research & Application: Endorsed by Inter-Society Color Council, The Colour Group (Great Britain), Canadian Society for Color, Color Science Association of Japan, Dutch Society for the Study of Color, The Swedish Colour Centre Foundation, Colour Society of Australia, Centre Français de la Couleur 2001;26:340-350.
14. Paravina RD, et al. Effect of finishing and polishing procedures on surface roughness, gloss and color of resin-based composites. Am J Dent 2004;17:262-266.
15. Gómez-Polo C, et al. 3D Master Toothguide according to L*, C*, and h* coordinates. Color Res Appl 2015;40:518-24.
16. Turgut S, Bağış B. Diş hekimliğinde renk ve renk ölçüm yöntemleri. Atatürk Üniversitesi Diş Hekimliği Fakültesi Dergisi 2012;5:65-75.
17. Değirmenci A, Emine K. Sigara ve Renklendirici İçeceklerin Mine-Dentin Kompleksinin Rengi ve Refraktif İndeksi Üzerindeki Etkileri. Van Sağ Bil Derg 15:69-79.
18. Nalbant D, ve ark. Yaş, dental plak miktarı, oral hijyen uygulamaları ve renkli içecekler tüketilmesinin doğal diş rengi üzerindeki etkilerinin değerlendirilmesi. Acta Odontol Turc 2014;31:89-94.
19. Sari ME, Koyutürk AE, Çankaya S. Çocukların tükettiği yiyecek ve içeceklerin süt ve daimi diş rengine etkisi. Cumhuriyet Dent J 2011;14:18-23.
20. Pereira R, et al. Dental prophylaxis influence in tooth color assessment—Clinical study. J Esthet Restor Dent 2020;32:586-592.
21. Von Elm E, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Ann Inter Med 2007;147:573-577.
22. Calzada MT, et al. Association Between Tobacco Smoking, Dental Status and Self-perceived Oral Health in Elderly Adults in Colombia. J Cross-Cult Gerontol 2021;36:187-200.
23. Koopaeei MM, et al. General dentists', pediatric dentists', and endodontists' diagnostic assessment and treatment strategies for deep carious lesions: A comparative analysis. J Am Dent Assoc 2017;148:64-74.
24. Li M, et al. Dentist-related factors influencing the use of vital pulp therapy: a survey among dental practitioners in China. J Int Med Res 2019;47:2381-2393.
25. Al-Taweel FB, et al. Evaluation of technology-based learning by dental students during the pandemic outbreak of coronavirus disease 2019. Eur J Dent Edu 2021;25:183-190.
26. Sharif M, et al. Perception of dental students regarding online classes during the pandemic. Pak Armed Forces Med J 2020;70:S369-374.
27. Okubo SR, et al. Evaluation of visual and instrument shade matching. J Prosthet Dent 1998;80:642-648.
28. Maitin S, et al. Evaluation of spectrophotometer analysis of bulk-fill composites in various daily used beverages. Int J Med Biomed Stud 2019;3:334-341.
29. Choi J-H, et al. Comparative study of visual and instrumental analyses of shade selection. J J. Wuhan Univ Technol Mater Sci Ed 2010;25:62-67.
30. Paravina RD, et al. Color difference thresholds in dentistry. J Esthet Restor Dent 2015;27:S1-S9.
31. Joiner A, Luo W. Tooth colour and whiteness: A review. J Dent 2017;67:S3-S10.
32. Demirel M, Tuncdemir M. Influence of age, gender, and educational background on tooth color. Niger J Clin Pract 2019;22:162-166.
33. Esan TA, Olusile AO, Akeredolu PA. Factors influencing tooth shade selection for completely edentulous patients. J Contemp Dent Pract 2006;7:80-87.
34. Hasegawa A, et al. Color of natural tooth crown in Japanese people. Color Research & Application: Endorsed by Inter-Society Color Council, The Colour Group (Great Britain), Canadian Society for Color, Color Science Association of

Japan, Dutch Society for the Study of Color, The Swedish Colour Centre Foundation, Colour Society of Australia, Centre Français de la Couleur. 2000;25:43-48.

**35.** Kirli MÇ, Şen ÖG. Renklenmiş Kanal Tedavili Dört Farklı Olgunun Beyazlatma Tedavisi ile Estetiklerinin Yeniden Kazandırılması. Turkiye Klinikleri Dishekimligi Bilimleri Dergisi. 2021;27:514-520.

**36.** Silva ALF, et al. Stain resistance and surface roughness of CAD/CAM processed hybrid ceramic. Color Res Appl 2021;46:901-908.

**37.** Akman S, ve ark. Düsük ısı porselenlerinin rengine çay, kahve ve sigara dumaninin in vitro etkisi. Turkiye Klinikleri Dishekimligi Bilimleri Dergisi 2010;16:223.

**38.** Gozalo-Diaz D, Johnston WM, Wee AG. Estimating the color of maxillary central incisors based on age and gender. J Prosthet Dent 2008;100:93-98.

**39.** Hartmann R, Müller F. Clinical studies on the appearance of natural anterior teeth in young and old adults. Gerodontology 2004;21:10-16.

Cumhuriyet Dental Journal, 26(1): 42-46, 2023
DOI: https://doi.org/10.7126/cumudj.1213288

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 | Available online, ISSN: 1302-5805 e-ISSN: 2146-2852 | Publisher: Sivas Cumhuriyet Üniversitesi

# *Effect of Plastic Impression-Transfer Copings on the Dimensional Accuracy of Implant Impressions*

**Akın Coşkun[1-a*], Tuğçe Koyu[2-b], Gizem Yeşilyurt[3-c], Melih Ülgey[4-d], Oğuzhan Görler[4-e]**

[1] *Department of Prosthodontics, Faculty of Dentistry, University of Dokuz Eylül, Izmir, Türkiye*
[2] *Department of Prosthodontics, Faculty of Dentistry, Sivas Cumhuriyet University, Sivas, Türkiye*
[3] *Private Dental Clinic, Sivas, Türkiye*
[4] *Private Dental Clinic, Izmir, Türkiye*
**Corresponding author*

**Research Article**

*History*

*Received: 06/12/2022*
*Accepted: 23/01/2023*



**ABSTRACT**

***Objective:*** The purpose of this in vitro study was to evaluate the effect of plastic impression-transfer copings on the dimensional accuracy of close tray implant impressions.

***Material and Methods:*** A master model consisting of acrylic main material was created. Five parallel holes were drilled for the analogs. Special measuring spoons were prepared for the models created with self-hardening polymethyl methacrylate resin. Our research consisted of 2 groups. The first group consisted of five parts and the impression was taken using the Implant Plastic impression-transfer part coping method. The second group, on the other hand, consists of five parts, and this time measurements were taken without using the Plastic impression-transfer coping method. Vinylpolysiloxane impression material was used for both groups. At the end of the impression process, plaster models were made with type IV calculus. The plaster models were scanned with laboratory-type scanner and recorded in the measurement program. To create a standard operation between the groups, measurements were made of each analog from a certain reference point. Measurement results were recorded in millimeters and pairwise comparisons were made using Welch's t-test analysis.

***Results:*** How the plastic impression caps affect the measures was concluded by applying the t-test to each point. The deterioration in the measurements taken with the cap was lower for all distances compared to the measurements taken without the cap, but the difference was not significant ($p>0.05$).

***Conclusions:*** While the distortions seen in the right and left measured intervals were found as the expansion type, the distortions in the posterior and anterior intervals were determined as the compression type. Although there are dimensional changes in the measurements taken without the use of a cap, the findings were not found to be clinically significant.

***Key words:*** Dental Implant, Implant Impression Material, Plastic Impression-Transfer Coping, Dimensional Accuracy, Dental Impression Technique.

**a** acoskunster@gmail.com https://orcid.org/0000-0001-6718-9504 **b** dttugcekoyu@gmail.com https://orcid.org/0000-0002-2235-7540
**c** gzmyyrt@gmail.com https://orcid.org/0000-0002-8821-4489 **d** melihulgey@gmail.com https://orcid.org/0000-0001-5859-7071
**e** oguzhangorler@gmail.com https://orcid.org/0000-0001-6545-8811

*How to Cite: Coşkun A Koyu T, Yeşilyurt G, Ülgey M, Görler O. (2023) Effect of Plastic Impression-Transfer Copings on the Dimensional Accuracy of Implant Impressions, Cumhuriyet Dental Journal, 26(1):42-46.*

## Introduction

Edentulism is decreasing due to current treatment modalities and preventive criteria, but the extent of the aged population will continue to expand.[1] Considering common global population aging, edentulism will not only influence persons in developing nations; there will be an appropriate proportion of edentulous individuals in aging communities worldwide.[1] Nowadays implant treatment is very common for edentulism and patients' long-term gratification has been observed by many clinical studies.[2] Studies found 96-99% implant success in the mandible and 80-90% in the maxilla.[3]

Stresses from inappropriate dental prostheses cannot be neutralized in implants because of not require periodontal ligament support. Thus, the manufacture of prosthesis has to obtain the most available passive fit.[2] The absence of passive fit can cause several complications in both implants and dental prostheses. Screw loosening, occlusal disharmony, loss of prosthesis, and fracture of implant components can count as these complications.[2]

Accuracy of impression which transfers the inter-implant dimensions exactly as it is the most important issue to fulfill passive fit.[2] There are very important issues to make an accurate impression. The material used for impression, impression technique, tray type, splinting of impression copings, and angulation of implants affect the accuracy of implant impressions.[2] So far, numerous implant impression techniques and different impression-transfer materials have been analyzed considering accuracy. In general, implant impressions can categorize as direct or indirect techniques. In the direct techniques, the tray has an open area on the tray for unscrewing the impression copings. This technique is also known as the

open tray impression technique. While impression removal, all pieces are unfastened at the same time, and copings are fixed on the same screws in the direct technique. Indirect techniques have transfers that remain on the implants during the impression. These transfers are fastened to the analog after the impression tray is removed from the mouth. So, this technique is also named as closed tray impression technique. Both close-tray impression and open-tray impression techniques are recommended for the fabrication of implant prostheses. The close tray impression technique is widely used because of practical clinical application.[4]

The accuracy of the close tray impression technique with plastic impression copings and a positioning cylinder is the same as the open tray impression technique with non-splinted and splinted impression copings, beyond impression and cast materials. Plastic impression copings remaining in the impression may improve accuracy by preventing both impression copings and the coping-analog unit from rotating within the impression.[4]

Up to now, open or close tray impression techniques, different impression materials, impression coping materials and splinted impression copings have been investigated for affecting factors on the accuracy of implant impressions. Nevertheless, the findings are not always constant. There is a lack of consensus about the effect of plastic impression transfer coping on the dimensional accuracy of implant impression. Therefore, the aim of this study was to be presenting to literature evidence of the effect of plastic impression-transfer copings on the dimensional accuracy of implant impression. Accuracy of two different impression techniques were compared: closed-tray impression with transfer impression copings and closed-tray impression without transfer impression copings. The research hypothesis was that using plastic impression copings would influence the dimensional accuracy of the impression.[5-6]

## Material and Methods

### *Fabrication of the Master Model*

In this in vitro study, the auto-polymerizing acrylic resin was used for a master model from an edentulous maxilla mold (Probase Cold, Ivoclar, Vivadent Inc, Zurich). Five parallel holes were drilled in the middle of the arch and on the both sides canine and first molar region. Next, implant analogs (Moment Dental Implant Systems, Turkey) were placed in the drilled holes. After ensuring that analogs were parallel to each other, they were secured using auto-polymerizing acrylic resin leaving 1 mm of the implant platforms above the acrylic resin. Analogs were named from A to E from the posterior left to the posterior right (Figure 1).

### *Fabrication of Custom Trays*

Moment implant system's impression copings were fastened to the analogs. These conical impression copings which were fixed in the master model were covered with 2 layers of modeling wax to allow the standard thickness of impression material. Five identical 2 mm–thick custom impression trays were made using auto-polymerizing polymethyl methacrylate resin. Autopolymerizing polymethyl methacrylate resin was mixed by following the manufacturer's instructions. Each tray was customized perforated to relief pressure during the impression (Figure 2).

### *Impression Procedure*

This in vitro study consisted of 10 specimens divided into 2 groups of 5 each (Table 1). For the PI group, the conical impression copings and then the plastic impression copings were fastened. All impressions were made with additional silicone (Zhermack Elite HD+ Regular Body, Kouigo, Italy) in a temperature-controlled environment (23 ± 1°C) according to the manufacturer's instructions and specification number 19 of ADA. Impression material was mixed by an auto-mixing cartridge.12 mL of the impression material was inserted around the copings to make sure covering they copings. The impression tray was filled with the rest of the impression material (35 mL). According to the manufacturer's recommendation, 12 minutes was the waiting time for impression material polymerization. Once the impression had been obtained, the conical transfer impression copings were removed from the mouth and fastened to the implant analogs. Then this analog and impression coping unit were positioned by firmly pushing in each plastic impression coping which was in the impression tray.

For the NON-PI group, only the conical impression copings were fastened to the analogs. Then same impressions protocol was repeated for this group. Once the impression had been obtained, the conical transfer impression copings were removed from the mouth and fastened to the implant analogs. Then this analog and impression coping unit were inserted by pushing into each respective notch (Figure 3).

### *Cast preparation*

After impression protocol, casts were made from type IV dental stones (Herostonel Vigodent Inc., Rio de Janeiro, RJ, Brazil). According to the manufacturer's instructions, the powder/water ratio was 30 g/7 mL, and the dental stone was vacuum mixed. 120 minutes was the waiting time for pouring then the impression was separated from the cast (Figure 4). All laboratory procedures were performed by the same operator.

### *Measurement Protocol*

The measurement phase started after completing laboratory procedures. Lab-type scanner (D15®; Camcube, Montreal, Canada) was used for scanning casts (Figure 5). After the scanning protocol, data were transferred to the measurement program (UP3D Manager).

### *Statistical Analysis*

Data were saved as millimeters. Welch's t-test was used to make pairwise comparisons. t-test was applied for each distance. A significant level was $p<0.05$.

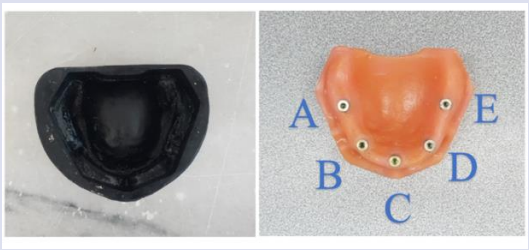



Figure 1. Edentulous maxilla mold (a), a master model with analogs (b)

Figure 2. Custom trays

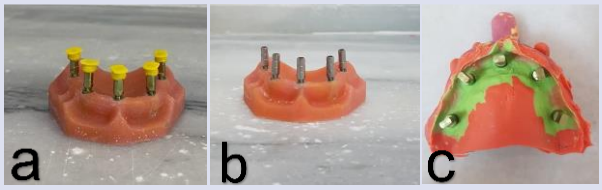



Figure 3. Master model was fastened impression copings and plastic transfer impression copings (a, group 1), master model was fastened impression copings (b, group 2), impression had been obtained and analog-impression coping unit positioned in the impression (c)

Figure 4. Casts before scanning

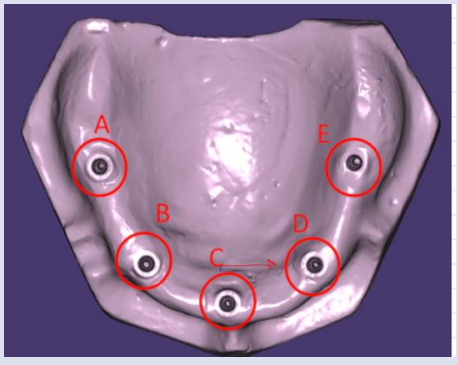



Figure 5. Scanned cast

## Results

This study aimed to determine if plastic impression-transfer coping affects dimensional accuracy. For all impressions used one master model. Five casts were made for each study group (Table 2-3). All specimens were measured and involved in the analyses. A specific reference corner was chosen in each analog to ensure standardization. The distortion seen in the impression taken without the plastic impression-transfer coping was higher than the impression taken with the plastic impression-transfer coping for all the distances, but no significant differences were found ($p>0.05$).

## Discussion

This in vitro study was aimed to evaluate plastic impression coping on the dimensional accuracy of the implant impression. Research hypothesis, using plastic impression copings would influence the dimensional accuracy of the impression, was rejected. Plastic impression copings influenced the dimensional accuracy of the impression but it was not statistically significant.

For a prosthesis to be successful, there must be a passive fit between the abutments and frameworks of the prosthesis.[7] Dimensional accuracy of impression is the key to a successful prosthesis and the impression must duplicate the clinical situation exactly.[8] To date, researchers focused on the aspects which affect the accuracy of impressions.[9]

First, implant components used in impression, conical impression copings, affect the accuracy.[7] According to Tan, impression copings significantly affect dimensional accuracy of impression.[9] Moment dental implant systems were used for this study. The second factor is the impression technique. Closed-tray technique was chosen in this in vitro study. In this point, several studies have evaluated and reported that the three-dimensional accuracy of the close tray impression technique is acceptable when inter-implant angulations were up to 15°.[2,10,11]

The type of the impression material is the third factor affects the accuracy of impression. There are plenty of in vitro studies that evaluated the dimensional accuracy of impression materials.[12,13] Additional silicone was used in this study. Because according to the literature, additional silicone has reasonable properties for implant impression.[7]

The dimensional change of dental stone is another aspect. This issue may cause the abutment replica's displacement in the cast. Type IV dental stone was used in this in vitro study. Anusavice[14] reports that type IV dental stone has at most 0.10% expansion of linear setting. Consequently, the expansion of dental stones can cause displace impression coping or abutment replicas. Nakhaei *et al.*[14] reports that the dimensional accuracy of implant impression techniques usually uses two-dimensional measurements. In this study, the lab-type scanner has been used to compare distances in the master model and in the definitive casts because it measures possible

distortions in three-dimension. This factor increases the veracity of this study.

The objective of this in vitro study was to be presenting new evidence to the literature about the effect of plastic impression-transfer copings on the dimensional accuracy of implant impressions. Thus, the null hypothesis indicating using plastic impression copings makes no difference in the dimensional accuracy of implant impressions was accepted. Results of this study show that plastic transfer impression copings increase measurement accuracy, but no clinically significant differences were found as consistent with the findings of Nakhaei *et al.* and Arieli *et al.*[14,15]

Also, methodological difficulty in the research design must be taken into account. As above mentioned above except for impression coping design, impression material, dental stone type; the presence of saliva, patient movement during the impression, change in the time from the impression until the master cast is obtained, the laboratory process may affect the definitive accuracy. Further studies are needed to determine the effect of plastic implant transfer coping on dimensional accuracy of implant impression with an angulated implant**.** This in vitro study is proof that using plastic impression-transfer copings help operators to transfer the exact position of an implant to the working cast.

## Conclusions

According to this in vitro study:

1. Distortions in the anterior-posterior distances were found compression type.
2. Distortions in the right-left distances were found as expansion-type.
3. Dimensional change was found the impression using without plastic impression-transfer coping, but no clinically significant differences were found.

**Table 1.** Study Groups

| Study Groups (n=5) | |
|---|---|
| PI | Close tray impression with plastic impression copings |
| NON-PI | Close tray impression without plastic impression copings |

**Table 2.** Measurements of Group PI (Close tray impression with plastic impression copings).

| **MASTER MODEL** | | **1.MODEL** | |
|---|---|---|---|
| A1-B1 | 18.373 | A1-B1 | 18.361 |
| A1-C1 | 31.881 | A1-C1 | 32.06 |
| A1-D1 | 40.403 | A1-D1 | 40.384 |
| A1-E1 | 43.383 | A1-E1 | 43.351 |
| **2.MODEL** | | **3.MODEL** | |
| A1-B1 | 18.367 | A1-B1 | 18.622 |
| A1-C1 | 31.834 | A1-C1 | 32.197 |
| A1-D1 | 40.486 | A1-D1 | 40.602 |
| A1-E1 | 43.105 | A1-E1 | 43.718 |
| **4.MODEL** | | **5.MODEL** | |
| A1-B1 | 18.371 | A1-B1 | 18.403 |
| A1-C1 | 31.924 | A1-C1 | 31.923 |
| A1-D1 | 40.21 | A1-D1 | 40.281 |
| A1-E1 | 43.286 | A1-E1 | 43.081 |

**Table 3.** Measurements of Group NON-PI (Close tray impression without plastic impression copings)

| **MASTER MODEL** | | **1.MODEL** | |
|---|---|---|---|
| A2-B2 | 18.373 | A2-B2 | 18.528 |
| A2-C2 | 31.881 | A2-C2 | 32.166 |
| A2-D2 | 40.403 | A2-D2 | 40.374 |
| A2-E2 | 43.383 | A2-E2 | 43.687 |
| **2.MODEL** | | **3.MODEL** | |
| A2-B2 | 18.247 | A2-B2 | 18.704 |
| A2-C2 | 31.891 | A2-C2 | 32.145 |
| A2-D2 | 40.563 | A2-D2 | 40.232 |
| A2-E2 | 43.902 | A2-E2 | 43.229 |
| **4.MODEL** | | **5.MODEL** | |
| A2-B2 | 18.468 | A2-B2 | 18.432 |
| A2-C2 | 31.992 | A2-C2 | 31.998 |
| A2-D2 | 40.34 | A2-D2 | 40.19 |
| A2-E2 | 43.34 | A2-E2 | 43.25 |

## References


1. Nuzzolese E, Lepore MMI, Cukovic-Bagic FM, Vella G D. Forensic sciences and forensic odontology. International Dental Journal 2008;58(6): 342–348.
2. Tabesh M, Alikhasi M, Siadat H. A Comparison of implant impression precision: Different materials and techniques. Journal of Clinical and Experimental Dentistry 2018;10(2): 151–157.
3. Aguilar M L, Elias A, Vizcarrondo C E T, Psoter W J. Analysis of three-dimensional distortion of two impression materials in the transfer of dental implants. Journal of Prosthetic Dentistry 2010;103(4):202–209.
4. Chang WG, Vahidi F, Bae KH, Lim BS. Accuracy of three implant impression techniques with different impression materials and stones. The International Journal of Prosthodontics 2012;25(1): 44–47.
5. Alsharbaty MHM, Alikhasi M, Zarrati S, Shamshiri AR. A Clinical Comparative Study of 3-Dimensional Accuracy between Digital and Conventional Implant Impression Techniques. Journal of Prosthodontics 2019;28(4): 902–908.
6. Moura RV, Kojima AN, Saraceni CHC, Bassolli L, Balducci I, Özcan M, Mesquita AMM. Evaluation of the Accuracy of Conventional and Digital Impression Techniques for Implant Restorations. Journal of Prosthodontics 2019;28(2): 530–535.
7. Fernandez M A, Paez de Mendoza CY, Platt JA, Levon JA, Hovijitra ST, Nimmo A. A comparative study of the accuracy between plastic and metal impression-transfer copings for implant restorations. Journal of Prosthodontics 2013;22(5): 367–376.
8. Hariharan R, Shankar M D S C, Rajan MDSM. Evaluation of Accuracy of Multiple Dental Implant. The International Journal of Oral & Maxillofacial Implants 2010;25(1):38-44.
9. Tan JZH, Tan MY, See Toh YL, Wong KY, Tan KBC. Three-dimensional positional accuracy of intraoral and laboratory implant scan bodies. J Prosthet Dent. 2022 Oct;128(4):735-744.
10. Alshawaf B, Weber HP, Finkelman M, El Rafie K, Kudara Y, Papaspyridakos P. Accuracy of printed casts generated from digital implant impressions versus stone casts from conventional implant impressions: A comparative in vitro study. Clin Oral Implants Res. 2018 Aug;29(8):835-842.
11. Alikhasi M, Siadat H, Nasirpour A, Hasanzade M. Three-Dimensional Accuracy of Digital Impression versus Conventional Method: Effect of Implant Angulation and Connection Type. Int J Dent. 2018 Jun 4;2018:3761750.
12. Punj A, Bompolaki D, Garaicoa J. Dental Impression Materials and Techniques. Dent Clin North Am. 2017 Oct;61(4):779-796.
13. Bandiaky ON, Le Bars P, Gaudin A, Hardouin JB, Cheraud-Carpentier M, Mbodj EB, Soueidan A. Comparative assessment of complete-coverage, fixed tooth-supported prostheses fabricated from digital scans or conventional impressions: A systematic review and meta-analysis. J Prosthet Dent. 2022 Jan;127(1):71-79.
14. Nakhaei M, Madani AS, Moraditalab A, Haghi HR. Three-dimensional accuracy of different impression techniques for dental implants. Dent Res J (Isfahan) 2015; Sep-Oct;12(5):431-437.
15. Arieli A, Adawi M, Masri M, Weinberg E, Beitlitum I, Pilo R, Levartovsky S. The Accuracy of Open-Tray vs. Snap on Impression Techniques in A 6-Implant Model: An In Vitro 3D Study. Materials (Basel). 2022 Mar 12;15(6):2103.

Cumhuriyet Dental Journal, 26(1): 47-53, 2023
DOI: https://doi.org/10.7126/cumudj.1228789

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 | Available online, ISSN: 1302-5805 e-ISSN: 2146-2852 | Publisher: Sivas Cumhuriyet Üniversitesi

# *Evaluation of Color Stability and Remineralization Capacity of Dual Effect Desensitizing Agents on Bleached Enamel with Hydrogen Peroxide*

**Hanife Altınışık[1-a]*, Cemile Kedici Alp[1-b]**

[1] *Department of Restorative Dentistry, Faculty of Dentistry, Gazi University, Ankara, Türkiye*
**Corresponding author*

**Research Article**

*History*

*Received: 03/01/2023*
*Accepted: 30/01/2023*



**ABSTRACT**

***Objectives:*** The aim of the study was to evaluate the effects on enamel calcium and phosphorus content and color stability of double-acting desensitized varnishes applied to bovine tooth enamel bleached with 40% hydrogen peroxide.

***Material and Methods:*** The coronal part of 10 newly extracted bovine teeth (approximately 10x12mm in size) was divided into 5 regions for mineral exchange measurements. To evaluate the color change, 50 newly extracted bovine teeth were divided into 5 groups. Group 1 unbleached (negative control group), Group 2 was bleached with 40%HP (positive control group), Groups 3, 4 and 5 were treated MI varnish, Clinpro White and Profluoroid varnish after bleaching, respectively. Then, all groups were exposed to the tea solution and enamel color measurements were made using the CIE Lab method with spectrophotometer. Mineral change measurements were determined by EDS and morphological changes were observed using SEM. One-way ANOVA, Tukey HSD tests and Tamhane's tests were used for statistical analysis.

***Results:*** The content of calcium and phosphorus in enamel were like No bleaching>MI varnish>Clinpro White>Profluoroid>Bleaching. The most color stability after bleaching was determined in teeth which were applied MI varnish applied group ($p<0.05$). The color stability of Profluoroid and Clinpro White applied group were similar ($p>0.05$). There was a statistically significant difference between the groups in terms of $\triangle L$ and $\triangle b$ averages ($p<0.05$).

***Conclusions:*** MI, Clinpro White and Profluoroid varnish used after bleaching were effective in preventing mineral loss from tooth enamel and reducing the susceptibility of tooth enamel to staining with tea.

***Key words:*** Bleaching, Desensitizing Agents, Remineralization, SEM-EDS, Color Stability.

a *hanife.kamak@hotmail.com* *https://orcid.org/0000-0001-7430-4750* b *cemile-kedici@hotmail.com* *https://orcid.org/0000-0002-1847-1367*

*How to Cite: Altınışık H, Kedici Alp C. (2023) Evaluation of Color Stability and Remineralization Capacity of Dual Effect Desensitizing Agents on Bleached Enamel with Hydrogen Peroxide, Cumhuriyet Dental Journal, 26(1):47-53.*

## Introduction

Today, individuals not only want to have healthy teeth, but also want to have a perfect smile.[1] White teeth are considered to be associated with both health and beauty and are preferred by patients. The demand for bleaching treatments is increasing with rising living standards and the increased aesthetic expectations.[2]

Dental bleaching is a safe, effective and minimally invasive treatment for tooth discoloration[3] and is a more conservative approach compared to porcelain crowns and composite laminate veneer restorations.[4] Dental bleaching can be performed by using home and in- office bleaching techniques. Home bleaching is usually applied to 10-22% carbamide peroxide or 4-10% hydrogen peroxide, while in-office bleaching is applied to 20-38% hydrogen peroxide or 35% carbamide peroxide.[5] In-office bleaching is preferred more in dentistry practice as it will provide faster whitening results with less application compared to home bleaching techniques.[6]

Although dental bleaching is a minimally invasive treatment, it causes some adverse effects on dental hard tissues. The most common adverse effect is tooth sensitivity.[7] The others are microscopic changes such as increased porosity and surface irregularities[8], an increase in surface roughness[9] and a decrease in hardness,[10] a decrease in mineral content of enamel.[11] Changes in the enamel surface after bleaching will create a porous structure and facilitate the precipitation of various color pigments in these pores. This will accelerate the discoloration process on the tooth surface exposed to bleaching. Therefore, this process can be prevented by removing the rough enamel surfaces.[12] For this purpose, using a dual-action product consisting of desensitizing and remineralizing agents during or after the bleaching treatment not only relieves tooth sensitivity but can also decrease the potential negative effects of peroxides on enamel structure.[13]

Fluoride varnish acts as a slow-release reservoir of fluoride, developed to keep fluoride on the tooth surface longer. Addition of calcium phosphate salts such as casein phosphopeptide-amorphous calcium phosphate (CPP-ACP), tri-calcium phosphate (TCP) to increase the effect of the varnish can improve the remineralization of

enamel.[14,15] TCP is functionalized (fTCP) by ball milling beta-tricalcium phosphate with sodium lauryl sulfate. During the production process, a protective barrier is created that helps calcium coexist with fluoride ions around it but prevents unwanted reaction between them during storage. It releases calcium and fluoride when it comes into contact with saliva after application.[15] CPP-ACP buffers free calcium and phosphate ion activities, helping to maintain a stage of supersaturation relative to tooth enamel, which suppresses demineralization and strengthens remineralization.[16] One study reported that CPP-ACP application to the tooth surface exposed to 35% HP decreased the incidence and severity of tooth sensitivity.[17] Studies have reported that enamel surface hardness increases, and roughness decreases after CPP-ACP is applied to enamel whose roughness increases and hardness decreases because of bleaching.[13,18] For these reasons, the application of these agents after bleaching can reduce the absorption of pigments as well as promote remineralization and greater surface sealing, resulting in greater color stability.

The aim of this study is to evaluate and compare the effects on enamel Ca and P content and color stability of double-acting products applied to enamel bleached with 40% HP. The following null hypotheses were tested: 1) the bleaching treatment does not affect Ca and P content of the enamel; 2) dual-acting products applied after bleaching do not affect Ca and P content of the enamel; 3) dual-acting products applied after bleaching do not have a significant effect on reducing the susceptibility of tooth enamel staining with black tea.

## Material and Methods

### *Specimen preparation*

In this study, 50 freshly extracted bovine teeth without caries, cracks, or demineralized surfaces were used. Periodontal ligament and gingival tissues were cleaned using a scalpel. The teeth were stored in distilled water before use. The crown was removed from the root and buccal enamel specimens were obtained. 10 specimens (approximately 10x12mm in size) were divided into 5 parts (each part was used in a separate group n=10) to assess the effect of bleaching and postbleaching dual-acting desensitizing agents on enamel Ca and P concentration. 50 specimens were used to assess the effect of bleaching and postbleaching dual-acting desensitizing agents on color stability. The specimens were washed in an ultrasonic bath to eliminate the dirty of enamel surface and then were embedded in translucent acrylic resin.

### *Bleaching procedure and surface treatments*

The specimens were divided into 5 groups (n=10).

Group A (negative control group): No bleaching procedure was performed.

Group B (positive control group): At first, in-office bleaching gel containing 40% HP (Opalesence Boost, Ultradent, South Jordan, Utah, USA) was applied twice, and each application time was 20 minutes.

Group C (MI Varnish): At first, in-office bleaching gel containing 40% HP (Opalesence Boost, Ultradent, South Jordan, Utah, USA) was applied twice, and each application time was 20 minutes. After the bleaching, MI (GC, Tokyo, Japan) varnish were applied to enamel blocks, dried with air water spray, and waited for 10 minutes.

Group D (Clinpro Varnish): At first, in-office bleaching gel containing 40% HP (Opalesence Boost, Ultradent, South Jordan, Utah, USA) was applied twice, and each application time was 20 minutes. After the bleaching, Clinpro White (3M ESPE, MN, USA) varnish was applied to enamel blocks, dried with air water spray, and waited for 10 minutes.

Group E (Profluoroid varnish): At first, in-office bleaching gel containing 40% HP (Opalesence Boost, Ultradent, South Jordan, Utah, USA) was applied twice, and each application time was 20 minutes. After the bleaching, Profluoroid (VOCO GmbH. Cuxhaven, Germany) varnish were applied to enamel blocks, dried with air water spray, and waited for 10 minutes.

### *Staining protocol*

After bleaching protocols were completed, the specimens were immersed in black tea (Lipton Yellow Label, Unilever, Istanbul, Turkey) solution (prepared by soaking 1 bag of black tea in 200 ml of boiled water for 5 minutes) for 10 min per day for two weeks. The solution was prepared freshly at every day. After that washed and immersed in distilled water during all day. This cycle was repeated for 2 weeks.

### *Color measurement*

Color measurements were performed using Vita Easyshade 5 spectrophotometer (Vita Zahnfabrik, Bad Sackingen, Germany) in accordance with CIELAB system. In this system, L* represents brightness (white-black range), a* represents red-green color range, and b* represents yellow-blue color range The spectrophotometer was calibrated in compliance with the manufacturer's instructions before each measurement. Removable plates were prepared on an acrylic block using an essix plate (1.0 mm Essix C; Dentsply, USA) on a vacuum press machine (Scheu Ministar, Germany) to standardize the color measurement site on the specimens. Then standard windows (R=7mm) were prepared on the plate corresponding to the areas to be measured on the specimens. The color parameters (L, a, and b values) of each sample were measured with a spectrophotometer from these opened windows. All color measurements for each specimen were made for each evaluation time point, at same room and standard light source by a single trained operator.

The measurements were performed after baseline ($T_0$), bleaching ($T_1$), and staining protocol ($T_2$). Baseline is defined as the time before bleaching protocols applied. The color differences between $T_1$-$T_0$, $T_2$-$T_0$ were

represented by $\Delta E_{ab}$*(T1), $\Delta E_{ab}$* (T2) respectively and calculated as follows:

$\Delta E_{ab}$*(T1)=[(ΔL1-L0*)$^2$+(Δa1-a0*)$^2$+(Δb1-b0*)$^2$]$^{1/2}$

$\Delta E_{ab}$*(T2)=[(ΔL2-L0*)$^2$+(Δa2-a0*)$^2$+(Δb2-b0*)$^2$]$^{1/2}$

$\Delta E_{ab}$ =$\Delta E_{ab}$ *(T2)- $\Delta E_{ab}$ *(T1)

### *Scanning Electron Microscopy (SEM) Energy Dispersive Spectrometry (EDS)*

After the sample was air-dried, it was fixed on aluminum plates and gold plated. Then, surface topography images were taken with a Scanning Electron Microscope (FE-SEM, Hitachi SU5000, Hi-Tech., Ltd.Japan) at 5000X magnifications with an acceleration voltage of 10 kV. Calcium and phosphorus content of enamel surfaces in each group were determined by EDS.

### *Statistical Analysis*

In this study, IBM SPSS Statistics 22 program was used for statistical analysis. Kolmogorov-Smirnov and Shapiro-Wilks tests were used to evaluate the suitability of the parameters to the normal distribution. It was determined that the parameters in this study were suitable for the normal distribution. While evaluating the datas, to compare between groups the Oneway Anova test was used, and the Tukey HDS test was used if the variances of the groups were homogeneous, and Tamhane's T2 test was used if they were not homogeneous. Significance was evaluated at the p<0.05 level.

## Results

### *Color Stability Measurement*

There was a statistically significant difference between the groups in terms of △E averages (p:0.001; p<0.05). As a result of Tamhane's T2 test performed to determine which groups the significance originates from; although there was no significant difference between the △L mean of the non-bleaching group and the MI varnish group (p>0.05), it was significantly higher than the bleaching group (p:0.012; p:0.007; p<0.05). There was no statistically significant difference between Clinpro White and Proflouoroid groups (p>0.05).

There was a statistically significant difference between the groups in terms of △L averages (p:0.012; p<0.05). As a result of the Tukey HSD test performed to determine which groups the significance originated from; although there was no significant difference between the △L mean of the unbleached group and the MI varnish group (p>0.05), it was significantly higher than the bleaching group (p:0.006; p:0.000; p<0.05). There was no statistically significant difference between Clinpro White and Profluoroid groups (p>0.05). The procedures used in this study did not effect △a values. There was no statistically significant difference between the groups in terms of mean △a (p:0.349; p>0.05).

There was a statistically significant difference between the groups in terms of △b averages (p:0.001; p<0.05). As a result of Tamhane's T2 test performed to determine which groups the significance originates from; although there was no significant difference between the △b mean of the non-bleaching group and the MI varnish group (p>0.05), it was significantly higher than the bleaching group (p:0.001; p:0.002; p<0.05). There was no statistically significant difference between Clinpro White and Profluoroid groups (p>0.05).

### *SEM EDS Analysis*

Evaluation of Ca and P values of the groups are shown in Table 2. The graphical comparison is also shown in Figure 1. There was a statistically significant difference in the groups of calcium averages (p:0.001; p<0.05). As a result of Tamhane's T2 test performed to determine which groups the significance originates from; the amount of calcium and phosphorus in MI varnish group were significantly higher than the Bleaching, Clinpro White and Profluoroid (p:0.001; 0.001; 0.001; respectively p<0.05). The amount of calcium and phosphorus in the unbleached group were significantly higher than the Bleaching, Clinpro White and Profluoroid (p:0.001; 0.001; 0.001; respectively p<0.05). The amount calcium and phosphorus of the Clinpro White group were significantly higher than the Bleaching and Profluoroid groups (p:0.001; 0.001; respectively p<0.05). The amount of calcium and phosphorus in Profluoroid group were significantly higher than the Bleaching group (p:0.001; p<0.05). There was no statistically significant difference between the non-bleaching and MI varnish groups (p>0.05).

Evaluation △L, △a, △b and △E of the groups are shown in Table 3. The graphical comparison is also shown in Figure 2. The amount of phosphorus in Clinpro White group was significantly higher than Bleaching and Profluoroid groups (p:0.001; 0.010; respectively p<0.05). Phosphorus mean of the Profluoroid group was significantly higher than that of the Bleaching group (p:0.001; p<0.05). There was no statistically significant difference between the non-bleaching and MI varnish groups (p>0.05).

SEM images were taken at 5000X magnifications to compare differences in the surface topography of groups (Figure 3). SEM image of unbleached enamel (control) (A) with smooth surface morphology and a small incidence of porosities, bleached enamel (B) with serious surface changes such as complete removal of the aprismatic layer and increased depth of enamel irregularities, enamel treated with MI varnish after bleaching (C) with the formation of a superficial mineral layer and organized nanocluster, enamel treated with Clinpro White varnish after bleaching (D) with the presence of a superficial mineral layer, but with the presence of numerous and various sizes of pores in some areas, and enamel treated with Profluoroid varnish after bleaching with the presence of a superficial mineral layer, but with the prism centers not closing completely in some regions.

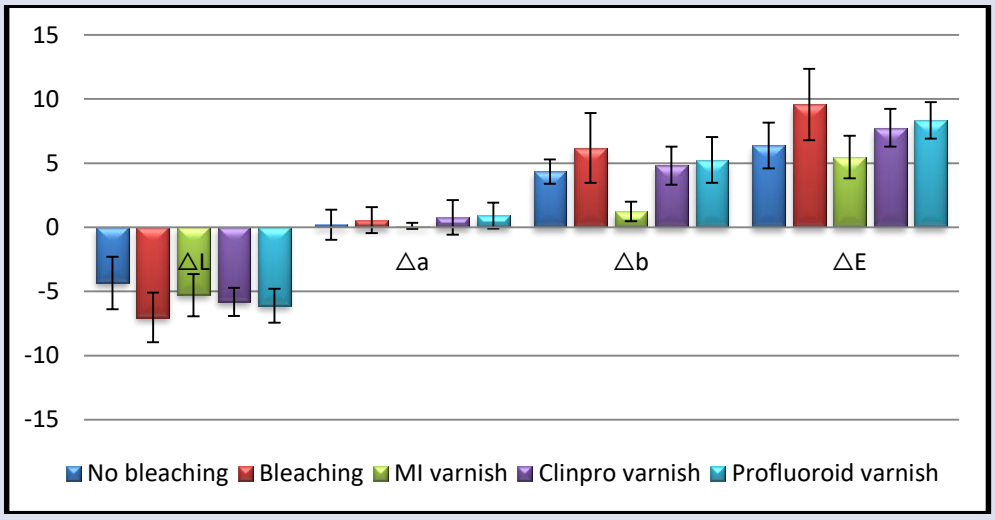



Figure 1. Evaluation of the groups in terms of △L, △a, △b and △E.

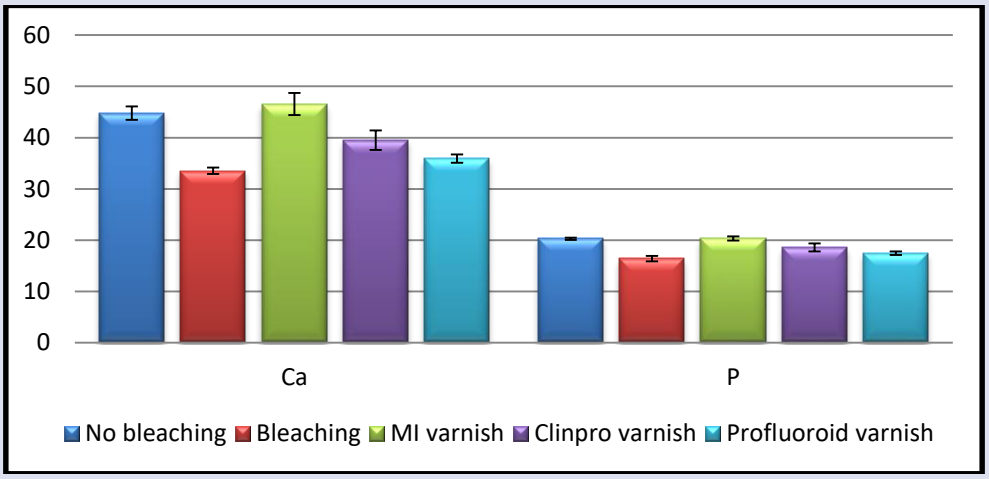



Figure 2. Evaluation of groups in terms of calcium (C) and phosphorus (P).

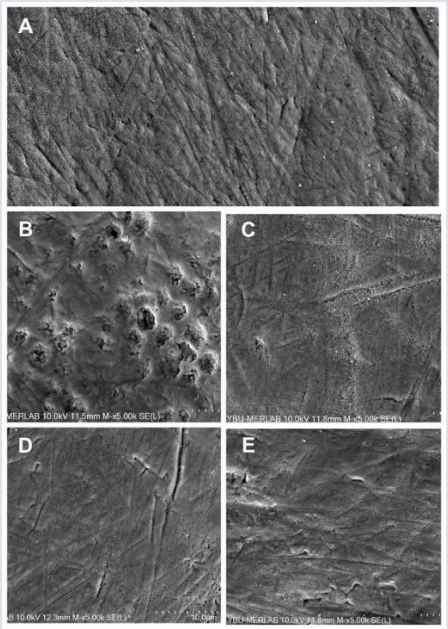



Figure 3. Representative scanning electron microphotographs of enamel surfaces(5000X) (A) Unbleached enamel, (B) Bleached enamel, (C) MI varnish after bleaching, (D)ClinPro varnish after bleaching, (E) Profluoroid varnish after bleaching

## Discussion

Bleaching agents lighten the discolored tooth by the decomposition of peroxides into free radicals. These radicals convert big pigmented molecules of enamel tissue into less pigmented smaller molecules through reduction and oxidation reactions.[19] Although studies on the effect of bleaching agents on dental tissue are conflicting,[20, 21] it is widely agreed that peroxides can alter the mineral content of teeth.[22] Lee *et al.* reported a significant decrease in the Ca/P ratio of bovine enamel bleached with 30% HP. In another study, the effects of 10% CP on mineral change and surface properties of enamel were investigated, and it was reported that as a result of bleaching, the Ca/P ratio and the Ca, P concentrations of the enamel decreased, and local changes resembling the initial tooth decay occur in the tooth enamel.[11] In this study, Ca and P concentrations of enamel bleached with 40% HP were statistically significantly lower compared to the control group consistent with the results of previous studies. Therefore, the first hypothesis of the study was rejected.

Morphological defects and change in mineral content caused by bleaching can be treated by the application of remineralizing agents. Considering that the incidence of tooth sensitivity after bleaching is very high,[7] dual-acting products containing both desensitizing and remineralizing agents can be used after bleaching. In this study, Profluoroid, Clinpro White and MI varnish were used from these products. The lack of using saliva as a remineralizing agent after in-office bleaching may be the limitation of this study. Because saliva plays an important role in protecting enamel from mineral loss and allows enamel remineralization.[23, 24] Vargas *et al.*[25] report that saliva acts as an alkalizing agent and helps reverse the effects of bleaching. However, in this study, the specimens were stored in distilled water instead of artificial saliva during the study period to analyze the effects of both the bleaching agent and the double-acting products used after bleaching on the chemical composition and surface morphology of the enamel.

Cochrane *et al.*[26] reported that MI varnish released higher levels of fluoride and calcium ions compared to other varnishes containing Ca and F, and thus had a better remineralization potential. Another study reported that CPP-ACP cream was more effective at remineralizing eroded enamel than fluoride varnish, fluoride toothpaste, fTCP varnish.[27] Rani *et al.*[28] reported that varnish containing CPP-ACP has a superior protective potential compared to varnishes containing F and fTCP. These findings are consistent with the results of this study, in which MI varnish applied after bleaching showed the highest remineralization potential. Some studies reported that Clinpro White varnish has more remineralization efficiency than MI varnish.[15, 29] In a study comparing the effects of 5% sodium fluoride varnish with/without fTCP, it was reported that the addition of fTCP significantly increased the remineralizing ability of the varnish.[30] Shen *et al.*[31] and Rani *et al.*[28] evaluated the ability of various varnishes to inhibit enamel demineralization. It was reported that all varnishes containing F significantly inhibit enamel demineralization, but varnishes containing calcium phosphate and F are more effective than varnishes containing only F. In addition, MI varnish reported higher levels of Ca and P release than Clinpro White varnish, consistent with the findings of this study. Therefore, the second hypothesis was also rejected.

Application of these substances after bleaching can promote remineralization and greater surface sealing, as well as reduce the absorption of pigments and provide greater color stability.[32] In this study, there was no significant difference between the amount of color change in the group treated with MI varnish after bleaching and in the unbleached group. The color stability of the groups treated with Clinpro White and Profluoroid varnish after bleaching was higher than the bleached group only, and lower than the unbleached group. Therefore, the third hypothesis was rejected. Total color change (ΔE) in study groups is attributed to the shift of the "L" parameter to the negative direction and the positive direction of the "a" and "b" parameters. In other words, the parameter “L” shifted to darker tones, “a” more red and “b” more yellow. The fact that black tea contains yellow dyes with different polarities can explain this situation. The results are consistent with the results of the studies of Karadaş and Seven[33], Amorim *et al.*[34] The “L” and “b” parameters had the greatest effect on ΔE; is consistent with previous studies.[32, 35, 36] Singh *et al.*[32] showed that tea has a significant effect on the color change of newly bleached enamel, and this effect is manifested by the negative (darker) shift of the “ΔL” parameter. Another study reports that the bleached group had the highest L* means, while the groups treated with CPP-ACP and F had the lowest L* mean after the unbleached group,[37] consistent with the findings of this study.

Chen *et al.*[38] reported that exposure to coffee and tea during the bleaching treatment did not affect the efficacy of the treatment, but exposure after the bleaching adversely affected the efficacy of the treatment. Considering that the changes in enamel after bleaching are responsible for its sensitivity to staining, the use of CPP-ACP, fTCP and F after bleaching can be very beneficial in terms of stability of the treatment result and reduction of tooth hypersensitivity. In addition, administration of these agents can also assist in removing the dietary restrictions that are usually recommended for patients after bleaching treatment.

## Conclusions

Within the limitations of the current study, in-office bleaching resulted in reduced Ca and P in enamel. The use of dual-acting agents such as MI, Clinpro White and Profluoroid varnish applied after bleaching was effective in replacing mineral loss from enamel and reducing the susceptibility of tooth enamel to staining with tea. MI varnish provides the most remineralization, followed by Clinpro White varnish and Profluoroid, respectively. MI

varnish is most effective in reducing discoloration with tea. However, there is no difference between Clinpro White and Profluoroid varnishes.

## Acknowledgements

The authors thank Central Research Laboratory Application and Research Center of Ankara Yıldırım Beyazıt University and Polat Narin for technical support.

## Funding

This study was funded by the authors. Products were not provided by the manufacturers.

## Conflict of Interest

The authors declare no conflict of interest for the authorship and/or publication of this article.

**Table 1.** The materials used in this study and their compositions

| Product | Manufacturer | Composition (w/w) |
|---|---|---|
| MI Varnish | GC, Tokyo, Japan | 30-50% polyvinyl acetate, 10-30% hydrogenated rosin, 20-30% ethanol, 1-8% sodium fluoride, 1-5% CPP-ACP, 1-5% silicon dioxide |
| Clinpro White Varnish | 3M ESPE, MN, USA | 30-75% pentaerythritol glycerol ester of colophony resin, 10-15% n-hexane, 1-15% ethyl alcohol, 1-5% sodium fluoride, 1-5% flavour enhancer, 1-5% thickener, 1-5% food grade flavour, <5% modified tricalcium phosphate |
| Profluorid varnish | VOCO GmbH. Cuxhaven, Germany | 5%sodium fluoride, ethanolic colophony |
| Opalescence Boost Office Bleaching Agent | Ultradent, USA | 40% hydrogen peroxide, thickeners, 1.1% sodium fluoride, 3% potassium nitrate, pH regulators. |

**Table 2.** Evaluation of the groups in terms of △L, △a, △b and △E.

| | △L | △a | △b | △E |
|---|---|---|---|---|
| | **Mean±SD** | **Mean±SD** | **Mean±SD** | **Mean±SD** |
| No bleaching | -4.05±1.53a | 0.20±1.18a | 2.40±0.33a | 4.91±1.27a |
| Bleaching | -7.73±1.07b | 0.56±1.01a | 6.18±2.72b | 10.10±2.30b |
| MI varnish | -4.99±1.10a | 0.12±0.24a | 1.24±0.76a | 5.19±1.12a |
| Clinpro varnish | -5.82±1.09c | 0.74±1.31a | 3.64±0.58c | 7.04±1.06c |
| Profluoroid varnish | -5.96±1.10c | 0.81±1.00a | 3.75±0.61c | 7.19±0.89c |
| p | 0.012* | 0.349 | 0.001* | 0.001* |

*Oneway ANOVA Test* **p<0.05*
*Different letters in the columns indicate the difference between groups.*

**Table 3.** Evaluation of groups in terms of calcium and phosphorus.

| | Ca | P |
|---|---|---|
| | **mean±SD** | **mean±SD** |
| No bleaching | 44.76±1.30a | 20.26±0.23a |
| Bleaching | 33.52±0.63b | 16.36±0.53b |
| MI Varnish | 46.54±2.15a | 20.31±0.39a |
| Clinpro varnish | 39.51±1.90c | 18.57±0.78c |
| Profluoroid varnish | 35.92±0.83d | 17.43±0.34d |
| p | 0.001* | 0.001* |

*Oneway ANOVA Test* **p<0.05*
*Different letters in the columns indicate the difference between groups.*

## References

1. Joiner A. Tooth colour: a review of the literature. Journal of dentistry. 2004; 32 Suppl 1:3-12.
2. Kihn PW. Vital tooth whitening. Dent Clin North Am. 2007; 51:319-331, viii.
3. Zantner C, Beheim-Schwarzbach N, Neumann K, Kielbassa AM. Surface microhardness of enamel after different home bleaching procedures. Dental materials : official publication of the Academy of Dental Materials. 2007; 23:243-250.
4. Kury M, Moura Antonialli F, LE SS, Pereira Machado Tabchoury C, Giannini M, Esteban Florez FL, et al. Effects of violet radiation and nonthermal atmospheric plasma on the mineral contents of enamel during in-office dental bleaching. Photodiagnosis Photodyn Ther. 2020; 31:101848.
5. Rezende M, Ferri L, Kossatz S, Loguercio AD, Reis A. Combined Bleaching Technique Using Low and High Hydrogen Peroxide In-Office Bleaching Gel. Oper Dent. 2016; 41:388-396.
6. Mena-Serrano AP, Garcia E, Luque-Martinez I, Grande R, Loguercio AD, Reis A. A Single-Blind Randomized Trial About the Effect of Hydrogen Peroxide Concentration on Light-Activated Bleaching. Oper Dent. 2016; 41:455-464.
7. Rezende M, Coppla FM, Chemin K, Chibinski AC, Loguercio AD, Reis A. Tooth Sensitivity After Dental Bleaching With a Desensitizer-containing and a Desensitizer-free Bleaching

Gel: A Systematic Review and Meta-analysis. Oper Dent. 2019; 44:E58-e74.
8. Ferreira Sda S, Araújo JL, Morhy ON, Tapety CM, Youssef MN, Sobral MA. The effect of fluoride therapies on the morphology of bleached human dental enamel. Microsc Res Tech. 2011; 74:512-516.
9. Martin JM, de Almeida JB, Rosa EA, Soares P, Torno V, Rached RN, et al. Effect of fluoride therapies on the surface roughness of human enamel exposed to bleaching agents. Quintessence Int. 2010; 41:71-78.
10. Borges AB, Samezima LY, Fonseca LP, Yui KC, Borges AL, Torres CR. Influence of potentially remineralizing agents on bleached enamel microhardness. Oper Dent. 2009; 34:593-597.
11. Potocnik I, Kosec L, Gaspersic D. Effect of 10% carbamide peroxide bleaching gel on enamel microhardness, microstructure, and mineral content. Journal of endodontics. 2000; 26:203-206.
12. China AL, Souza NM, Gomes Ydo S, Alexandrino LD, Silva CM. Effect of fluoride gels on microhardness and surface roughness of bleached enamel. Open Dent J. 2014; 8:188-193.
13. Yesilyurt C, Sezer U, Ayar MK, Alp CK, Tasdemir T. The effect of a new calcium-based agent, Pro-Argin, on the microhardness of bleached enamel surface. Australian dental journal. 2013; 58:207-212.
14. Rirattanapong P, Vongsavan K, Saengsirinavin C, Pornmahala T. Effect of fluoride varnishes containing tri-calcium phosphate sources on remineralization of initial primary enamel lesions. Southeast Asian J Trop Med Public Health. 2014; 45:499-504.
15. Elkassas D, Arafa A. Remineralizing efficacy of different calcium-phosphate and fluoride based delivery vehicles on artificial caries like enamel lesions. Journal of dentistry. 2014; 42:466-474.
16. Reynolds EC, Cai F, Shen P, Walker GD. Retention in plaque and remineralization of enamel lesions by various forms of calcium in a mouthrinse or sugar-free chewing gum. Journal of dental research. 2003; 82:206-211.
17. Nanjundasetty JK, Ashrafulla M. Efficacy of desensitizing agents on postoperative sensitivity following an in-office vital tooth bleaching: A randomized controlled clinical trial. Journal of conservative dentistry : JCD. 2016; 19:207-211.
18. Heshmat H, Ganjkar MH, Jaberi S, Fard MJ. The effect of remin pro and MI paste plus on bleached enamel surface roughness. Journal of dentistry (Tehran, Iran). 2014; 11:131-136.
19. Haywood VB. History, safety, and effectiveness of current bleaching techniques and applications of the nightguard vital bleaching technique. Quintessence Int. 1992; 23:471-488.
20. Miranda CB, Pagani C, Benetti AR, Matuda Fda S. Evaluation of the bleached human enamel by Scanning Electron Microscopy. J Appl Oral Sci. 2005; 13:204-211.
21. Oltu U, Gürgan S. Effects of three concentrations of carbamide peroxide on the structure of enamel. J Oral Rehabil. 2000; 27:332-240.
22. Al-Salehi SK, Wood DJ, Hatton PV. The effect of 24h non-stop hydrogen peroxide concentration on bovine enamel and dentine mineral content and microhardness. Journal of dentistry. 2007; 35:845-850.
23. Grazioli G, Valente LL, Isolan CP, Pinheiro HA, Duarte CG, Münchow EA. Bleaching and enamel surface interactions resulting from the use of highly-concentrated bleaching gels. Arch Oral Biol. 2018; 87:157-262.
24. Basting RT, Rodrigues AL, Jr., Serra MC. The effects of seven carbamide peroxide bleaching agents on enamel microhardness over time. J Am Dent Assoc. 2003; 134:1335-1342.
25. Vargas-Koudriavtsev T, Herrera-Sancho Ó A. Effect of tooth-bleaching on the carbonate concentration in dental enamel by Raman spectroscopy. J Clin Exp Dent. 2017; 9:e101-e106.
26. Cochrane NJ, Shen P, Yuan Y, Reynolds EC. Ion release from calcium and fluoride containing dental varnishes. Australian dental journal. 2014; 59:100-105.
27. Memarpour M, Soltanimehr E, Sattarahmady N. Efficacy of calcium- and fluoride-containing materials for the remineralization of primary teeth with early enamel lesion. Microsc Res Tech. 2015; 78:801-806.
28. Rani KB, Ramanna PK, Mailankote S, Joy AK, Thomas AA, Baby M. Evaluation of Anticaries Efficacy of Various Fluoride Varnishes on Artificial Enamel Lesion: An In Vitro Study. J Contemp Dent Pract. 2021; 22:774-777.
29. Zhou SL, Zhou J, Watanabe S, Watanabe K, Wen LY, Xuan K. In vitro study of the effects of fluoride-releasing dental materials on remineralization in an enamel erosion model. Journal of dentistry. 2012; 40:255-263.
30. Alamoudi SA, Pani SC, Alomari M. The effect of the addition of tricalcium phosphate to 5% sodium fluoride varnishes on the microhardness of enamel of primary teeth. Int J Dent. 2013; 2013:486358.
31. Shen P, Bagheri R, Walker GD, Yuan Y, Stanton DP, Reynolds C, et al. Effect of calcium phosphate addition to fluoride containing dental varnishes on enamel demineralization. Australian dental journal. 2016; 61:357-365.
32. Singh RD, Ram SM, Shetty O, Chand P, Yadav R. Efficacy of casein phosphopeptide-amorphous calcium phosphate to prevent stain absorption on freshly bleached enamel: An in vitro study. Journal of conservative dentistry : JCD. 2010; 13:76-79.
33. Karadas M, Seven N. The effect of different drinks on tooth color after home bleaching. Eur J Dent. 2014; 8:249-253.
34. Amorim AA, de Arruda CNF, Vivanco RG, Bikker F, de Pires-de-Souza FCP. Effect of phytosphingosine on staining resistance and microhardness of tooth enamel. Journal of esthetic and restorative dentistry : official publication of the American Academy of Esthetic Dentistry [et al]. 2021; 33:294-302.
35. Wiegand A, Drebenstedt S, Roos M, Magalhães AC, Attin T. 12-month color stability of enamel, dentine, and enamel-dentine samples after bleaching. Clinical oral investigations. 2008; 12:303-310.
36. Alaghemand H, Hashemi Kamangar SS, Zarenegad N, Tabari N, Abedi H, Khafri S. In-Vitro Effect of Casein Phosphopeptide Amorphous Calcium Phosphate on Enamel Susceptibility to Staining by Tea during Bleaching Treatment. Journal of dentistry (Tehran, Iran). 2015; 12:607-613.
37. Públio JC, D'Arce MB, Brunharo NM, Ambrosano GM, Aguiar FH, Lovadino JR, et al. Influence of surface treatments on enamel susceptibility to staining by cigarette smoke. J Clin Exp Dent. 2013; 5:e163-8.
38. Chen YH, Yang S, Hong DW, Attin T, Yu H. Short-term effects of stain-causing beverages on tooth bleaching: A randomized controlled clinical trial. Journal of dentistry. 2020; 95:103318.

Cumhuriyet Dental Journal, 26(1): 54-62, 2023
DOI: https://doi.org/10.7126/cumudj.1228802

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 | Available online, ISSN: 1302-5805 e-ISSN: 2146-2852 | Publisher: Sivas Cumhuriyet Üniversitesi

# *Perspectives of the Dental Educators with Regard to Online Education*

***Tugba Aydin[1-a], Ahmet Bedreddin Sahin[1-b*]***

[1] *Department of Periodontology, Faculty of Dentistry, Atatürk University, Erzurum, Türkiye.*
**Corresponding author*

**Research Article**

*History*

*Received: 03/01/2023*
*Accepted: 20/02/2023*

**ABSTRACT**

***Objectives:*** The purpose of this study is the evaluation of the perspectives of the educators in Faculties of Dentistry with regard to online education.

***Materials and Methods:*** It was requested from the educators of the Faculties of Dentistry to fill in a questionnaire about their perspectives on online education including overall assessment statements. The questionnaire was delivered to the participants as a paper-based or online version. The data were evaluated using descriptive statistics and multiple logistical regression analysis.

***Results:*** 350 valid responses were received by the educators over the course of 15 days. By means of our results, we determined that the educators accommodate themselves to the online education on easy terms. However, fewer educators found online education advantageous over face-to-face education. In addition, during online education, it was mostly given a negative opinion as to students' class attendance, class participation, and learning success can be controlled or not. According to the results of the multiple logistical regression analysis, it was shown that the positive opinions of the educators in terms of their perspectives about online education can be increased with the increase in weekly course hours and the current technological infrastructure situation, and can be decreased with the increase in tenure.

***Conclusions:*** Our study shows that the perspectives of the educators with regard to online education were not positive. However, the results demonstrate that the perspectives of the educators for online education can change with various factors.

***Keywords:*** Dental Education; Dental School; Online Education; Survey.

*Süreç*

*Geliş: 03/01/2023*
*Kabul: 20/02/2023*

**ÖZ**

***Amaç:*** Bu çalışmanın amacı, diş hekimliği fakültelerindeki öğretim üyelerinin çevrimiçi eğitime bakış açılarının değerlendirilmesidir.

***Gereç ve Yöntemler:*** Diş hekimliği fakültelerindeki öğretim üyelerinden, çevrimiçi eğitime bakış açıları ile ilgili genel değerlendirme ifadeleri içeren bir anket doldurmaları istendi. Anket, katılımcılara kağıt üzerinde veya çevrimiçi olarak ulaştırıldı. Veriler, tanımlayıcı istatistikler ve çoklu lojistik regresyon analizi ile değerlendirildi.

***Bulgular:*** Öğretim üyelerinden on beş gün boyunca 350 geçerli yanıt alındı. Bulgularımız aracılığıyla öğretim üyelerinin çevrimiçi eğitime uyum sağlayabildiğini belirledik. Ancak çevrimiçi eğitimi, yüz-yüze eğitime göre avantajlı bulan öğretim üyesi daha azdı. Ayrıca çevrimiçi eğitim sırasında öğrencilerin, derse devamlarının, derse katılımlarının ve öğrenme başarılarının kontrol edilebildiği/edilebileceği konusunda çoğunlukla olumsuz görüş bildirildi. Çoklu lojistik regresyon analizi sonuçlarına göre öğretim üyelerinin, çevrimiçi eğitimle ilgili bakış açılarındaki olumlu görüşlerinin, haftalık verilen ders saati ve mevcut teknolojik altyapı durumunun iyileşmesiyle artabileceği, görev süresinin artmasıyla azalabileceği gösterildi.

***Sonuçlar:*** Çalışmamız, öğretim üyelerinin, çevrimiçi eğitime bakış açılarının olumlu olmadığını göstermektedir. Ancak sonuçlar, öğretim üyelerinin online eğitime bakış açılarının çeşitli faktörlerle değişebileceğini göstermektedir.



***Anahtar Kelimeler:*** Diş Hekimliği Eğitimi; Diş Hekimliği Fakültesi; Çevrimiçi Uzaktan Eğitim; Anket.

a dtkoseoglu@hotmail.com https://orcid.org/0000-0002-9675-5509 b temhabsahin@hotmail.com https://orcid.org/0000-0002-4742-9627

*How to Cite: Aydın T, Şahin AB. 2023) Perspectives of the Dental Educators with Regard to Online Education, Cumhuriyet Dental Journal, 26(1):54-62.*

## Introduction

Distance education is characterised by the teaching-learning process in which the relationship between the educator and the student does not occur physically.[1,2] The use of distance education can be considered as one of the indicators of the adaptability of countries, institutions, and even individuals to the era they are in and to the accessed technology.[3] However, online education is defined as a newer version of distance education that enhances access to education through the use of certain technologies.[4,5]

Online education provides the student to learn at his/her own pace with fast and easy access to the Materials. In addition, it enables him/her to receive education without dealing with certain expenses such as transportation and accommodation.[2] Another advantage of online education is claimed to be providing students with easier and more effective access to more diverse and more numerous information.[6] With the developing technology, it is only reasonable to take advantage of online education. The health professionals in the USA argue that online education should be adopted in schools of dentistry of the country in order to take advantage of the opportunities online education offers.[7,8] However, digital transformation is considered a slow process in schools of dentistry.[9,10] In addition, practical training and clinical training are essential in the pre-clinical curriculum in the education of dentistry. This makes people think that online education feasible in the future will include only the theoretical educational content of the education of dentistry.[10]

In March 2020, the Covid-19 pandemic caused an unprecedented change in the education of dentistry by necessitating the need for online education.[11] In December 2019, Coronavirus Disease 2019 (Covid-19), characterised by pneumonia-like symptoms, was firstly reported in Wuhan City, Hubei Province, China. The virus spread rapidly and caused a worldwide epidemic. On March 11, 2020, the first Covid-19 case was seen in Turkey, and on the same date, World Health Organisation (WHO) explained that this newly emerged virus is a pandemic.[12,13] The Covid-19 pandemic has caused a great impact on the health system and the education of dentistry.[14,15] In Turkey on March 16, 2020, primary and secondary schools and higher education institutions were closed off. On March 23, 2020, Turkey's Council of Higher Education announced that the online education process would begin in all the universities with the available infrastructure because of the pandemic. Many educators and students had to adapt to online education suddenly. This rapid shift to online education brought up various concerns and questions. In addition to creating the need, this pandemic can also provide the chance to accelerate digital transformation in the education of Dentistry.[16] Therefore, the perspectives of both the educators and the students with regard to online education should be taken into consideration so that online education is developed efficiently and the raised concerns are addressed.

In the literature, many studies have focused on the perspectives of the students with regard to online education[17-19] For all we know, there is a limited number of studies that evaluate the perspectives of educators with regard to online education.[10,20] For this reason, the aim of this study is the evaluation of the perspectives of the dental educators in Turkey with regard to online education by means of the questionnaire. The null hypothesis of this study was that the perspectives of the dental educators with regard to online education would be positive.

## Materials and Methods

The study protocol for this study is approved by the Ethics Committee of the Ataturk University, Faculty of Dentisry (decision date being June 22, 2022; issue no. 67). The study was conducted in accordance with the Declaration of Helsinki. This survey was carried out between June-July 2022. The questionnaire that was used was the altered version of the questionnaires which were developed by Schlenz *et al.*[10], and Alsoufi *et al.*[21] and were studied in terms of their reliability. Before being finalised, a preliminary test was subjected to a small group of educators in order to ensure the clarity of the questionnaire. The questionnaire was developed in Turkish and its internal consistency was tested in a pilot study including 25 faculty of members. The sample taken from the pilot study has not been incorporated into the final analysis. To know the size of the target population, the data was taken from' ÖSYM's (Measuring, Selection and Placement Center) lastly published Higher Education Programs and Quotas Guide.[22] Accordingly, there are 2247 dental educators registered in the Faculties of Dentistry in Turkey. According to the target population, 329 answers was required to provide a 95% confidence range and 5% margin of error. The questionnaire was delivered to the dental educators in Turkey as a paper-based or online version. The paper version was distributed among the educators. The online version was sent via e-mail. The e-mail included an anonymous link to the questionnaire. For the questionnaire to be sent online, Google Forms was used. The educators who do not respond in the beginning were reinvited with a second e-mail. There was not any incentive to participate in the questionnaire. Personal information was not gathered in order to ensure safety and anonymity. This issue was emphasised to all the participants and clearly indicated at the beginning of the questionnaire. The paper-based questionnaires that are completed were gathered in a predetermined place by one of the researchers in order to ensure safety and avoid any response bias. In addition, only the fully-filled questionnaires were included in the study as for the online version. The participants were not aware of the goal or the results of the study in order to decrease any possible risk of bias.

Before the questionnaire, the participants were presented with the informed consent form and were asked to confirm that they read and understand the document.

The 27-item questionnaire was including general questions about the current technological infrastructure situation such as the perspective with regard to online education, proficiency in the use of electronic devices, and quality of the internet that was used along with basic demographic data such as gender and age. Section 1 was involving evaluative statements concerning online education infrastructure, and Section 2 concerning perspective with regard to online education. The participants were asked to agree/disagree the statements using a five-point Likert scale. Lastly, in Section 3, demographic questions were asked. Cronbach's Alpha has shown a high degree of reliability in terms of the questionnaires on technological infrastructure for online education (0.883) and perspective with regard to online education (0.935).

### *Statistical Analysis*

SPSS 20.0 for Windows (SPSS Inc., IL, ABD) program was used for the recording of the data and statistical evaluation. Descriptive statistics were used in order to analyse the answers that the participants gave to the questionnaires of demographic data, perspective with regard to online education, and current technological infrastructure situation for online education, using frequency and percentage. The categorical variables were defined as frequencies and percentages, and as mean (standard deviation) having appropriate continuous variables. Multiple logistical regression analysis was used to identify the simultaneous effects of age, tenure in educatorship, weekly course hours, academic title, and current technological infrastructure situation for online education, for each question in the questionnaire on perspective with regard to online education. For multiple logistical regression analysis, the participants who chose the options agree and strongly agree were gathered into a group and identified as “positive” and the participants who chose the options neutral, disagree, and strongly disagree were gathered into a group and identified as “neutral/negative”. The results were displayed as odds ratio and 95% confidence intervals. The results were considered statistically significant at $p < 0.05$.

## Results

### *Basic Demographic Characteristics*

350 fully-filled questionnaires were gathered in total from the dental educators in 28 different provinces of Turkey. 179 of the participants (51.1%) were female, and 171 of the participants (48.9%) were male. The mean age was 40.83 (±9.02). Most of the participants were assistant professor (137, 39.14%). 300 of the educators had not experienced online education before the Covid-19 pandemic. After the pandemic, the number of educators who did not experience online education was down to 28 people. The online education method that was experienced was mostly indicated as the combination of synchronous and asynchronous online learning (blended) (47.51%). The results with regard to the demographic data of the participants who responded are shown in Table 1.

**Table 1** Demographic characteristics of the respondents.

| Variable | n (%) | Variable | n (%) |
|---|---|---|---|
| Gender | | Weekly Course Hours | |
| Female | 179 (51.14) | 1-4 | 130 (37.15) |
| Male | 171 (48.86) | 5-8 | 98 (28) |
| | | 9-12 | 69 (19.71) |
| Age (in years) | | 13-16 | 34 (9.71) |
| 21-30 | 23 (6,57) | 16+ | 19 (5.43) |
| 31-40 | 180 (51.43) | | |
| 41-50 | 94 (26.86) | Experience in Online Education | |
| 51-60 | 39 (11.14) | Yes | 322 (92.00) |
| 61-70 | 14 (4) | No | 28 (8.00) |
| Areas of Expertise | | Experience in Online Education | |
| Oral and Maxillofacial Surgery | 37 (10.57) | before Covid-19 | |
| Maxillofacial Radiology | 46 (13.14) | Yes | 50 (14.29) |
| Endodontics | 35 (10) | No | 300 (85.71) |
| Ortodontics | 41 (11.71) | | |
| Pedodontics | 40 (11.43) | Experienced Education Method | |
| Periodontology | 54 (15.43) | Synchronous | 142 (44.10) |
| Prosthetic Dentistry | 54 (15.43) | Asynchronous | 27 (8.39) |
| Restorative Dentistry | 43 (12.29) | Blended | 153 (47.51) |
| Academic Title | | Tenure | |
| Lecturer | 24 (6.86) | 1-5 | 149 (42,57) |
| Assistant Professor | 137 (39.14) | 6-10 | 80 (22.86) |
| Associate Professor | 91 (26) | 11-15 | 51 (14,57) |
| Professor | 98 (28) | 16-20 | 27 (7.71) |
| Mean values of the answers given to the questionnaire on current technological infrastructure for online education | | | |
| ≤3 | 88 (25.14) | | |
| >3 | 262 (74.86) | | |

**Table 2** Distribution of responses to the current technological infrastructure situation survey for online education.

| Item description | Strongly disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| E1. I find myself sufficient in using electronic devices. | 3 (0.86) | 9 (2.57) | 75 (21.43) | 210 (60.00) | 53 (15.14) |
| E2. I find the technology of the electronic devices I use/will use for online education sufficient. | 3 (0.86) | 39 (11.14) | 87 (24.86) | 175 (50.00) | 46 (13.14) |
| E3. I find the quality and speed of my internet connection that I used/will use for online education as sufficient. | 15 (4.29) | 60 (17.14) | 117 (33.43) | 146 (41.71) | 12 (3.43) |
| E4. I find the infrastructure set up by my university for online education as sufficient. | 15 (4.29) | 66 (18.86) | 87 (24.86) | 156 (44.57) | 26 (7.42) |

Values are presented as n (%).

### *The Evaluation of the Current Technological Infrastructure Situation for Online Education among the Participants*

Four questions were used for the evaluation of the current technological infrastructure situations of the educators for online education. The vast majority of the participants (263, 75.14%) stated being sufficient in using the electronic devices, and similarly, the vast majority of the participants (221, 63.14%) stated that they found the technology of the electronic devices that they used as sufficient. Participants who found the quality and speed of the internet connection that they used as sufficient were less (158, 45.14%). The educators mostly stated that the infrastructure that their university set up for online education was sufficient (182, 51.99%). Table 2 summarises the findings with regard to the evaluation of the current technological infrastructure of the educators for online education. The mean value of the answers to the four questions given by one participant was calculated and results with regard to these values were presented in Table 1.

### *The Perspectives of the Educators with regard to Online Education*

Thirteen questions were used to evaluate the perspective with regard to online education. According to the answers taken from the questionnaire, the perspective of the dental educators was generally neutral/negative. As 156 of the educators (44.57%) stated that online education is a good method to teach the theoretical part of dental education, 171 of them (48.86%) stated that some parts of dental education should continue online education in the future. However, there were only 65 educators (18.57%) who found online education more advantageous than face-to-face education. 166 of the educators (47.43%) reported that online education would be easily implemented in the future. But negative opinion was given on the matter of whether class attendance (87, 24.86%), class participation (88, 25.14%), and learning success (100, 28.57%) can be controlled or not during online education. The majority of the educators gave a positive opinion in terms of feeling comfortable during online education (199, 56.86%) and not having a hard time adapting to online education (208, 59.43%). Table 3 summarises the findings concerning the questionnaire on the perspectives of educators with regard to online education.

The logistic regression model was implemented to investigate the impact of age, tenure in educatorship, weekly course hours, academic title, and current technological infrastructure situation for online education on the perspective with regard to online education (Table 4). It was found that the number of the educators who believe that online education is a good method for teaching the theoretical part of the dental education increases with the increase in weekly course hours (OR=1.05, CI: (1.01, 1.09); $p$ = 0.026) and current technological infrastructure situation (OR =1.54, CI: (1.11, 2.12); $p$=0.009), and decreases with the increase in tenure (OR=0.92, CI: (0.85, 0.99); $p$=0.034). In addition to this, lecturer gave 4.38 times more positive opinions than professors about online education being a good method for teaching the theoretical part of dental education (OR = 4.38, CI: (1.08, 17.81); $p$ = 0.039). It was demonstrated that the mean course hours per week of the educators who think positively about the continuation of some parts of dental education with online education are higher than people who selected neutral/ negative (Table 3). However, according to the multivariate logistic analysis that was done, there was not a meaningful relationship between weekly course hours and this situation. The number of educators that think online education is more advantageous than face-to-face education (OR=1.07, CI: (1.02, 1.12); $p$=0.004) and parts of dental education should continue in online education in the future (OR = 1.05, CI: (1.01, 1.10); $p$=0.019) increased with the increase in weekly course hours. The number of the educators who think parts of dental education should continue in online education in the future and online education can easily be implemented in the future increased with the increase in the current technological infrastructure situation ((OR=1.43, CI: (1.05, 1.96); $p$=0.024), (OR=1.43, CI: (1.05, 1.95); $p$=0.009)) and decreased with the increase in tenure ((OR=0.91, CI: (0.85, 0.99); $p$=0.020), (OR=0.90, CI: (0.84, 0.97); $p$=0.007)). In addition, it was found that the number of the educators who think that students could/will control their class attendance (OR=1.07, CI: (1.02, 1.12); $p$=0.004) and class participation (OR=1.07, CI: (1.02, 1.12); $p$=0.004) during online education, felt/will be feeling comfortable during online education (OR= 1.56, CI: (1.14, 2.14); $p$=0.006) and did not/will not have a hard time in adapting in online education (OR = 1.07, CI: (1.02, 1.12); $p$ = 0.004) increased with the increase in the current technological infrastructure situation. It was found that the mean age and tenure of the educators who think students could/will control their learning success during online education were higher than educators who think otherwise (Table 3). However, in the multivariate analysis, there was not a meaningful relationship between this situation and the age and tenure of the educators. In

addition, it was seen that the number of educators who think students could/will be feeling comfortable during online education just as in face-to-face education increased with the increase in weekly course hours (OR = 1.06, CI: (1.01, 1.11); *p*=0.010) and age (OR=1.09, CI: (1.01, 1.19); *p*=0.032).

## Discussion

Face-to-face dental training that has been applied worldwide over the years requires close contact (23, 24). With the Covid-19 pandemic, dental training has been revised almost all over the world in a way that fits the need for epidemic prevention in terms of social distance.[25] It is thought that this pandemic not only creates the need but also provides the chance to accelerate digital transformation in dental training.[16] Consistent with the literature, our results show that 272 educators experienced online education after the Covid-19 pandemic. In addition, the convenience and flexibility that online education offers seem to be contributing to the proliferation and popularity of this method.[26] Therefore, the efficient examination and development of online education will be beneficial. During our research, there was limited up-to-date information about the perspective of the dental educators with regard to online education.[10,20] This study is designed to investigate the perspectives of the educators with regard to online education. The results of this study brought out the neutral/negative perspectives of the educators with regard to online education. That said, the current study emphasises that age, tenure in educatorship, weekly course hours, academic title, and current technological infrastructure situation of the educators affects their perspectives with regard to online education. According to the results of our study, our null hypothesis is rejected.

For questionnaires in the healthcare field, the use of the Likert scale is acknowledged as standard procedure.[27-29] Therefore, the Likert scale was used in the current study for the investigation of the perspectives of educators with regard to online education. All the participants were informed that data collection was completely anonymous and the monitorability of the respondent was not allowed. Thus biasness while responding was attempted to be avoided.

According to the data taken from YÖK (Higher Education Program), 123 of the 207 universities in Turkey have the Distance Education Application and Research Center. There is no one distance education method for the universities at present. Universities use different online education methods such as synchronous and asynchronous according to the current infrastructure and the number of students.[30] Although every university has its online education methods, 182 (52%) of the educators who participated in the study stated that the infrastructure of the university in which they work is sufficient. The number of educators who stated otherwise is only 81 (23.14%). In addition, the vast majority of the educators who participated in the study stated that they found themselves sufficient in using the electronic devices (263, 70.1%), and the technology of the electronic devices that they used (221, 63.1%) was sufficient as well. Rota *et al.*[20], stated in their study that some educators have difficulties in synchronous and asynchronous online education methods because of slow internet connections and network problems. Consistent with this study, in our study, it was demonstrated that the current technological infrastructure situations of the educators may have an effect on their perspectives with regard to online education.

Educators who participated in the study of Schlenz *et al.*[10] mostly stated that online education is a good method to teach the theoretical part of dental education. However, in the current study, 156 (44.6%) educators agree with this opinion. This difference may be related to the considerable difference in the number of the participants and difference in the preparation and implementation of online education in different countries. In addition, it was shown that their ideas about online education being a good method to teach the theoretical part of dental education are affected by their tenure in educatorship, weekly course hours, and current technological infrastructure situations (Table 4).

There is no doubt that online education has many disadvantages along with many advantages in comparison with face-to-face education. Most of the educators who participated in the study of Idris *et al.*[31] defined online education as a way of learning new education techniques and being more productive and innovative. Meanwhile, the educators unfortunately felt that the students can not control their class attendance and learning success. Only 65 (18.6%) of the educators who participated in the current study stated that online education is more advantageous in many ways to teach the theoretical part of dental education in comparison with face-to-face education. This finding is reasonable since there are fewer educators who think students were/will be disciplined and careful during online education (78, 22.3%), students could/will be able to control their class attendance (87, 24.9%), students could/will be able to control their class participation (88, 25.1%) and students could/will be able to control their learning success (100, 28.6%). Having said that, although it was reported that students are kept from getting feedback with regard to their learning success because there is a weaker relationship that exists between the educator and the student in online education[32], it was indicated that proper designation and preparation of the online education are the strongest factors affecting the outcomes of a successful online education.[33] In addition, Wise *et al.*[34] showed that the efficacy of educators with regard to online education is not related to general tenure in educatorship, but related to the number of online course hours that were experienced. Educators having higher self-efficacy levels have more flexibility in the working environment and higher chances of making improvements in challenging situations.[35,36] They may be more willing to try new education methods.[37] The findings of our study are consistent with the study of Wise *et al.* in that the number of educators who think online education is more advantageous in many ways in comparison with face-to-face education only meaningfully increases with the increase in weekly course hours (Table 4). In addition, the findings of our study are consistent with the study of Wise *et al.* in that the number of

educators who think parts of dental education should continue in online education increases with the increase in weekly course hours and the current technological infrastructure situation (Table 4). However, the findings of our current study are not consistent with the finding which includes decreasing in the number of educators, who think parts of dental education should continue in online education and that online education can easily be implemented in the future, with the increase in tenure in educatorship. This difference might be considered to be related to the fact that the perspectives of educators from different countries with regard to online education and educator efficacies regarding online education can change in relation to different circumstances. Along with that, Rota *et al.*[20] stated that educators who participated in their study recommended continuing online education. Consistent with this study, in the current study, the number of educators who think parts of dental education should continue in online education (171, 48.9%) is higher than those who think otherwise (76, 21.7%).

**Table 3** Combined ratings descriptive statistics for the questionnaire on perspectives of educators with regard to online education

| Item description | Age | Academic Title n (%) | | Tenure | Course Hours | Technological Infrastructure |
|---|---|---|---|---|---|---|
| | mean±SD | 1 | 2 | mean±SD | mean±SD | mean±SD |
| **P1.** Online education is a good method to teach parts of dental education. | | | | | | |
| Positive response | 39.8±9.0 | 76 (40.2) | 80 (49.7) | 8.6±8.5 | 8.5±5.0 | 3.7±0.8 |
| Neutral/negative response | 41.6±8.9 | 113 (59.8) | 81 (51.3) | 10.9±9.1 | 6.7±5.8 | 3.4±0.7 |
| **P2.** Teaching the theoretical part of dental education without loss of content is possible with online education as well, as it is in face-to-face education. | | | | | | |
| Positive response | 40.8±10.3 | 49 (25.9) | 51 (31.7) | 10.3±10.6 | 8.6±6.2 | 3.7±0.9 |
| Neutral/negative response | 40.8±8.5 | 140 (74.1) | 110 (68.3) | 9.8±8.1 | 7.0±5.2 | 3.4±0.7 |
| **P3**. Online education is more advantageous for many ways in comparison with face-to-face education to teach the theoretical part of dental education. | | | | | | |
| Positive response | 40.8±8.9 | 34 (18) | 31 (19.3) | 9.8±8.3 | 9.6±4.9 | 3.7±0.8 |
| Neutral/negative response | 40.9±9.1 | 155 (82) | 130 (80.7) | 9.9±9.0 | 7.0±5.6 | 3.5±0.8 |
| **P4.** I think that online education is beneficial in teaching the theoretical part of dental education and that parts of dental education should continue in online education in the future. | | | | | | |
| Positive response | 39.9±8.8 | 84 (44.4) | 87 (54) | 8.7±8.4 | 8.4±5.1 | 3.6±0.8 |
| Neutral/negative response | 41.8±9.2 | 105 (55.6) | 74 (46) | 11.1±9.2 | 6.6±5.8 | 3.4±0.7 |
| **P5.** I think that online education will be easily implemented in the future to teach the theoretical part of dental education. | | | | | | |
| Positive response | 40.6±9.1 | 85 (45) | 80 (49.7) | 9.2±8.7 | 8.1±5.7 | 3.6±0.8 |
| Neutral/negative response | 41.1±9.0 | 104 (55) | 81 (51.3) | 10.5±9.0 | 6.9±5.3 | 3.4±0.7 |
| **P6.** I found/I think I will find students disciplined and careful during online education. | | | | | | |
| Positive response | 42.5±9.7 | 47 (24.9) | 31 (19.3) | 11.0±9.9 | 8.2±5.0 | 3.7±0.8 |
| Neutral/negative response | 40.4±8.8 | 142 (75.1) | 130 (80.7) | 9.6±8.6 | 7.3±5.7 | 3.5±0.7 |
| **P7.** I think I could control/I will be able to control the class attendance of the students during online education. | | | | | | |
| Positive response | 42.2±9.4 | 51 (27) | 36 (22.4) | 10.8±9.6 | 8.6±5.7 | 3.7±0.8 |
| Neutral/negative response | 40.3±8.8 | 138 (73) | 125 (77.6) | 9.6±8.6 | 7.1±5.4 | 3.4±0.7 |
| **P8.** I think I could control/I will be able to control the class participation of the students during online education. | | | | | | |
| Positive response | 43.2±10.0 | 54 (28.6) | 34 (21.1) | 12.1±10.0 | 8.0±4.4 | 3.7±0.7 |
| Neutral/negative response | 40.1±8.6 | 135 (71.4) | 127 (78.9) | 9.1±8.4 | 7.3±5.9 | 3.4±0.8 |
| **P9.** I think I could control/I will be able to control the learning success of the students during online education. | | | | | | |
| Positive response | 44.5±8.5 | 75 (39.7) | 25 (15.5) | 12.9±8.7 | 7.8±5.2 | 3.7±0.7 |
| Neutral/negative response | 39.4±0.8 | 114 (60.3) | 136 (84.5) | 8.7±8.8 | 7.3±5.7 | 3.5±0.8 |
| **P10.** I feel comfortable/I think I will feel comfortable during online education just as in face-to-face education. | | | | | | |
| Positive response | 41.1±9.5 | 102 (54) | 97 (60.2) | 10.0±9.5 | 8.4±5.7 | 3.6±0.8 |
| Neutral/negative response | 40.4±8.3 | 87 (46) | 64 (39.8) | 9.8±8.1 | 6.3±5.1 | 3.3±0.7 |
| **P11.** Online education was as satisfactory as face-to-face education/I believe it will be as satisfactory. | | | | | | |
| Positive response | 43.1±9.6 | 34 (18) | 22 (13.7) | 11.8±10.1 | 6.9±5.2 | 3.6±0.9 |
| Neutral/negative response | 40.4±8.8 | 155 (82) | 139 (86.3) | 9.6±8.6 | 7.6±5.6 | 3.5±0.7 |
| **P12.** Use of new digital teaching methods (e.g: online education) motivates me/I believe it will motivate me. | | | | | | |
| Positive response | 41.2±9.4 | 41 (21.7) | 33 (20.5) | 10.2±9.4 | 7.5±5.7 | 3.6±0.9 |
| Neutral/negative response | 40.7±8.9 | 148 (78.3) | 128 (79.5) | 9.8±8.7 | 7.5±5.5 | 3.5±0.7 |
| **P13.** I did not have a difficulty in online education/I believe I will not. | | | | | | |
| Positive response | 39.8±8.4 | 105 (55.6) | 103 (64) | 8.8±7.6 | 7.7±5.4 | 3.6±0.7 |
| Neutral/negative response | 42.4±9.6 | 84 (44.4) | 58 (36) | 11.6±10.3 | 7.2±5.8 | 3.4±0.8 |

- Values are presented as mean ± standard deviation (SD) or n (%).
- Academic Title (1: Professor and Associate Professor, 2: Assistant Professor and Lecturer)
- Positive response (Agree, Strongly agree)
- Neutral/negative response (Neutral, Disagree, Strongly Disagree)

**Table 4** Multiple logistic regression results for the questions of educators perspectives on online education.

| Dependent Variable | Independent Variable | Odds Ratio | 95% of CI | p-value |
|---|---|---|---|---|
| P1. Online education is a good method to teach parts of dental education. | Tenure (years) | 0.92 | 0.85-0.99 | 0.034* |
| | Course Hours (hours) | 1.05 | 1.01-1.09 | 0.026* |
| | Academic Title | | | |
| | Professor (Reference) | | | |
| | Associate Professor | 1.28 | 0.60-2.74 | 0.524 |
| | Assistant Professor | 1.46 | 0.60-3.58 | 0.401 |
| | Lecturer | 4.38 | 1.08-17.81 | 0.039* |
| | Technological Infrastructure | 1.54 | 1.11-2.12 | 0.009* |
| P3. Online education is more advantageous for many ways in comparison with face-to-face educationto teach the theoretical part of dental education. | Course Hours (hours) | 1.07 | 1.02-1.12 | 0.004* |
| P4. I think that online education is beneficial in teaching the theoretical part of dental education and that parts of dental education should continue in online education in the future. | Tenure (years) | 0.91 | 0.85-0.99 | 0.020* |
| | Course Hours (hours) | 1.05 | 1.01-1.10 | 0.019* |
| | Technological Infrastructure | 1.43 | 1.05-1.96 | 0.024* |
| P5. I think that online education will be easily implemented in the future to teach the theoretical part of dental education. | Tenure (years) | 0.90 | 0.84-0.97 | 0.007* |
| | Technological Infrastructure | 1.43 | 1.05-1.95 | 0.024* |
| P7. I think I could control/I will be able to control the class attendance of the students during online education. | Technological Infrastructure | 1.49 | 1.02-2.16 | 0.037* |
| P8. I think I could control/I will be able to control the class participation of the students during online education. | Technological Infrastructure | 1.52 | 1.05-2.20 | 0.025* |
| P10. I feel comfortable/I think I will feel comfortable during online education just as in face-to-face education. | Age (years) | 1.09 | 1.01-1.19 | 0.032* |
| | Course Hours (hours) | 1.06 | 1.01-1.11 | 0.010* |
| | Technological Infrastructure | 1.56 | 1.14-2.14 | 0.006* |
| P13. I did not have a difficulty in online education/I believe I will not. | Technological Infrastructure | 1.56 | 1.14-2.13 | 0.006* |

*Statistically significant at 0.05 significance level

Selvaraj *et al.*[38], in their study regarding online education carried out with students, stated that 63% of the students were not comfortable during online education. In addition, Schlenz *et al.*[10] stated that educators felt more comfortable during face-to-face education in comparison with online education. In contrast to these studies, the vast majority of the educators who participated in the current study (199, 56.9%) stated that they felt/will feel comfortable during online education just as in face-to-face education. That said, it is shown in our study that feeling comfortably increases with the increase in ages, weekly course hours, and current technological infrastructure situations of the educators. The reason for the findings being different than other studies may be related to the differences in ages and weekly course hours of the study population or different preparation and implementation of online education in different countries.

It has been shown in various studies that educators and students who participate in the study regarding online education can easily be adapted to online education.[10,39] In addition, in the study of Chang *et al.*[40], it was indicated that students adapt more quickly in comparison with senior educators since they are more familiar with technological devices. Consistent with this finding, in the current study, it was shown that the number of educators who think educators do not/will not have difficulty in adapting to online education increases with the increase in their current technological infrastructure situations.

Our study has provided a general analysis about the perspectives of educators with regard to online education. Due to a broad-based survey design including a random sample of the educators across Turkey, current results could be generalised without too much inherent bias. The possible limitation of this study was that it was carried out in one country. Thus, the results can not be generalised to other countries and there is the need for further studies being carried out in different countries and centers in order to achieve a general result with regard to online education.

## Conclusions

This study revealed that educators adapt to online education. In addition, although the current study had determined that educators carry neutral/negative perspectives with regard to online education, it has been shown that perspectives of the educators with regard to online education can change with factors such as age, tenure in educatorship, weekly course hours, academic title, and current technological infrastructure situation. Today, we can say that the results will change in time as faculties of dentistry gain more experience in online education.

## Conflicts of Interest Statement

The authors have no conflict of interests that may have influenced the design, execution, or presentation of the scholarly work.

### References


1. Freire LM, Paula MA, Duarte ED, Bueno M. Distance education in neonatal nursing scenarios: a systematic review. Rev Esc Enferm USP. 2015;49(3):515-521.
2. McCutcheon LRM, Alzghari SK, Lee YR, Long WG, Marquez R. Interprofessional education and distance education: A review and appraisal of the current literature. Curr Pharm Teach Learn. 2017;9(4):729-736.
3. Telli SG, Altun D. Coronavirüs ve çevrimiçi (online) eğitimin önlenemeyen yükselişi. Üniversite Araştırmaları Dergisi. 2020;3(1):25-34.
4. Benson AD. Using online learning to meet workforce demand: A case study of stakeholder influence. Quarterly review of distance education. 2002;3(4):443-452.
5. Conrad D. Deep in the hearts of learners: Insights into the nature of online community. Journal of Distance Education. 2002;17(1):1-19.
6. Mooney GA, Bligh JG. Information technology in medical education: current and future applications. Postgrad Med J. 1997;73(865):701-704.
7. Andrews KG, Demps EL. Distance education in the US and Canadian undergraduate dental curriculum. Journal of Dental Education. 2003;67(4):427-438.
8. Haden NK, Hendricson WD, Kassebaum DK, Ranney RR, Weinstein G, Anderson EL, et al. Curriculum change in dental education, 2003-09. J Dent Educ. 2010;74(5):539-557.
9. Hillenburg KL, Cederberg RA, Gray SA, Hurst CL, Johnson GK, Potter BJ. E-learning and the future of dental education: opinions of administrators and information technology specialists. Eur J Dent Educ. 2006;10(3):169-177.
10. Schlenz MA, Schmidt A, Wöstmann B, Krämer N, Schulz-Weidner N. Students' and lecturers' perspective on the implementation of online learning in dental education due to SARS-CoV-2 (COVID-19): A cross-sectional study. BMC medical education. 2020;20(1):1-7.
11. Zheng M, Bender D, Lyon C. Online learning during COVID-19 produced equivalent or better student course performance as compared with pre-pandemic: empirical evidence from a school-wide comparative study. BMC medical education. 2021;21(1):1-11.
12. Bakanlığı TC Saglık. COVID-19 Bilgilendirme Platformu 2020 [Available from: https://covid19.saglik.gov.tr.
13. WHO. WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020 [Available from: https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020.
14. Wu DT, Wu KY, Nguyen TT, Tran SD. The impact of COVID-19 on dental education in North America—Where do we go next? European Journal of Dental Education. 2020;24(4):825-827.
15. Gungor AS, Uslu YŞ, Dönmez N. Perceptions of dental students towards online education during the COVID-19 pandemic. European Oral Research. 2021;55(3):124-132.
16. Ebner M, Schön S, Braun C, Ebner M, Grigoriadis Y, Haas M, et al. COVID-19 epidemic as E-learning boost? Chronological development and effects at an Austrian university against the background of the concept of "E-Learning Readiness". Future Internet. 2020;12(6):94.
17. Varthis S, Anderson OR. Students' perceptions of a blended learning experience in dental education. Eur J Dent Educ. 2018;22(1):e35-e41.
18. Al-Taweel FB, Abdulkareem AA, Gul SS, Alshami ML. Evaluation of technology-based learning by dental students during the pandemic outbreak of coronavirus disease 2019. Eur J Dent Educ. 2021;25(1):183-190.
19. Coughlan J, Timus D, Crnic T, Srdoc D, Halton C, Dragan IF. Impact of COVID-19 on dental education in Europe: The students' perspective. Eur J Dent Educ. 2022;26(3):599-607.
20. Rota M, Peveri G, Fanelli M, Torelli L, Rocchi MB, Specchia C. Satisfaction with online teaching of medical statistics during the COVID-19 pandemic: A survey by the Education Committee of the Italian Society of Medical Statistics and Clinical Epidemiology. Teach Stat. 2021;43(3):129-139.
21. Alsoufi A, Alsuyihili A, Msherghi A, Elhadi A, Atiyah H, Ashini A, et al. Impact of the COVID-19 pandemic on medical education: Medical students' knowledge, attitudes, and practices regarding electronic learning. PloS one. 2020;15 (11): e0242905.
22. YÖK. Yükseköğretim Programları ve Kontenjanları Kılavuzu 2021 [Available from: https://yokatlas.yok.gov.tr.
23. Ather A, Patel B, Ruparel NB, Diogenes A, Hargreaves KM. Coronavirus disease 19 (COVID-19): implications for clinical dental care. Journal of endodontics. 2020;46(5):584-595.
24. Peng X, Xu X, Li Y, Cheng L, Zhou X, Ren B. Transmission routes of 2019-nCoV and controls in dental practice. Int J Oral Sci. 2020;12(1):9.
25. Quinn B, Field J, Gorter R, Akota I, Manzanares MC, Paganelli C, et al. COVID-19: The immediate response of european academic dental institutions and future implications for dental education. Eur J Dent Educ. 2020;24(4):811-814.
26. Harasim L. Shift happens: Online education as a new paradigm in learning. The Internet and higher education. 2000;3(1-2):41-61.
27. Andersen BR, Hinrich JL, Rasmussen MB, Lehmann S, Ringsted C, Løkkegaard E, et al. Social ties between team members affect patient satisfaction: a data-driven approach to handling complex network analyses. Advances in Health Sciences Education. 2020;25(3):581-606.
28. Norman G. Likert scales, levels of measurement and the "laws" of statistics. Adv Health Sci Educ Theory Pract. 2010;15(5):625-632.
29. Schlenz MA, Michel K, Wegner K, Schmidt A, Rehmann P, Wostmann B. Undergraduate dental students' perspective on the implementation of digital dentistry in the preclinical curriculum: a questionnaire survey. BMC Oral Health. 2020;20(1):78.
30. Di Carvalho Melo L, Bastos Silveira B, Amorim Dos Santos J, Cena JA, Dame-Teixeira N, Martins MD, et al. Dental education profile in COVID-19 pandemic: A scoping review. Eur J Dent Educ. 2022.
31. Idris F, Zulkipli IN, Abdul-Mumin KH, Ahmad SR, Mitha S, Rahman HA, et al. Academic experiences, physical and mental health impact of COVID-19 pandemic on students and lecturers in health care education. BMC Med Educ. 2021;21(1):542.
32. Baum S, McPherson M. Improving teaching: Strengthening the college learning experience. Daedalus. 2019;148(4):5-13.
33. Yang D. Instructional strategies and course design for teaching statistics online: perspectives from online students. Int J STEM Educ. 2017;4(1):34.
34. Wise SR. A Quantitative Correlational Study of Faculty Sense of Efficacy in Online Introductory Courses: Grand Canyon University; 2019.

**35.** Horvitz BS, Beach AL, Anderson ML, Xia J. Examination of faculty self-efficacy related to online teaching. Innovative Higher Education. 2015;40(4):305-316.
**36.** Tschannen-Moran M, Hoy AW. Teacher efficacy: Capturing an elusive construct. Teaching and teacher education. 2001;17(7):783-805.
**37.** Hampton D, Culp-Roche A, Hensley A, Wilson J, Otts JA, Thaxton-Wiggins A, et al. Self-efficacy and Satisfaction With Teaching in Online Courses. Nurse Educ. 2020;45(6):302-306.
**38.** Selvaraj A, Radhin V, Ka N, Benson N, Mathew AJ. Effect of pandemic based online education on teaching and learning system. Int J Educ Dev. 2021;85:102444.
**39.** Idris F, Zulkipli IN, Abdul-Mumin KH, Ahmad SR, Mitha S, Rahman HA, et al. Academic experiences, physical and mental health impact of COVID-19 pandemic on students and lecturers in health care education. BMC Medical Education. 2021;21(1):1-13.
**40.** Chang TY, Hsu ML, Kwon JS, Kusdhany MLS, Hong G. Effect of online learning for dental education in asia during the pandemic of COVID-19. J Dent Sci. 2021;16(4):1095-1101.

Cumhuriyet Dental Journal, 26(1): 63-68, 2023
DOI: https://doi.org/10.7126/cumudj.1242258

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 | Available online, ISSN: 1302-5805 e-ISSN: 2146-2852 | Publisher: Sivas Cumhuriyet Üniversitesi

# *The Roughening Effects of Er:YAG, Nd:YAG, and KTP Laser Systems on Root Dentin Surface*

***Recai Zan [1-a*], Hüseyin Sina Topçuoğlu [2-b], İhsan Hubbezoğlu [3-c], Demet Altunbaş [1-d], Arzu Şeyma Demir [4-e]***

*[1] Department of Endodontics, Faculty of Dentistry, Sivas Cumhuriyet University, Sivas, Türkiye.*
*[2] Department of Endodontics, Faculty of Dentistry, Kayseri Erciyes University, Kayseri, Türkiye.*
*[3] Department of Restorative Dentistry, Faculty of Dentistry, Sivas Cumhuriyet University, Sivas, Türkiye.*
*[4] Faculty of Dentistry, Sivas Cumhuriyet University, Türkiye.*
**Corresponding author*

**Research Article**

*History*

*Received: 30/01/2023*
*Accepted: 17/02/2023*

**ABSTRACT**

***Objectives:*** Present study aimed to evaluate the roughening ability of different laser systems on the middle and apical third of roots.

***Materials and Methods:*** Sixty extracted human single-rooted single canal mandibular premolar teeth were randomly assigned to 3 groups (*n*=20). Standardized preparation and sterilization procedures were performed. The samples were irradiated with Er:YAG, Nd:YAG, and KTP laser systems. The laser irradiations (1.5 Watt) were applied with a spiral motion, starting 1 mm short of the apex and then moving coronally for 10 sec, interleaved with 15-sec recovery intervals for each irradiation. This process was repeated twelve times. The roots that were standardized in the same length and thicknesses were divided parallel to the longitudinal axis. Then, the middle and apical 1/3 surface roughness values of each root section were measured using a profilometer and SEM analysis was performed. The data obtained were analysed using the two-way analysis of variance (ANOVA) and Tukey post-hoc tests.

***Results:*** According to measurements obtained from middle and apical 1/3 surfaces; Although, the statistically highest roughness value was determined after Nd:YAG laser ($p<0.05$), the statistically lowest value was detected following the Er:YAG laser irradiation ($p<0.05$).

***Conclusions:*** In light of the present study, all laser systems caused significant roughness in surfaces. Therefore, laser systems should be carefully applied in human root canals.

***Keywords:*** Laser; Endodontics; Nd:YAG; Er:YAG; SEM.

# Er:YAG, Nd:YAG ve KTP Lazer Sistemlerinin Kök Dentin Yüzeyindeki Pürüzlendirme Etkisi

*Süreç*

*Geliş: 30/01/2023*
*Kabul: 17/02/2023*

**ÖZ**

***Amaç:*** Bu çalışma, köklerin orta ve apikal üçlüsünde farklı lazer sistemlerinin pürüzlendirme kabiliyetini değerlendirmeyi amaçlamıştır.

***Gereç ve Yöntemler:*** Altmış çekilmiş tek kök tek kanallı insan mandibular premolar dişler rastgele olarak 3 gruba ayrıldı (n=20). Standart preparasyon ve sterilizasyon prosedürleri uygulandı. Örnekler Er:YAG, Nd:YAG ve KTP lazer sistemleri ile ışınlandı. Lazerlerle ışınlama (1,5 Watt) apeksin 1 mm yukarısından spiral hareketlerle başlanarak koronale doğru 10 sn boyunca uygulandı ve her ışınlama sonrası 15 sn beklenildi. Bu prosedür 12 kez tekrarlandı. Eşit uzunluk ve kalınlıkta standardize edilen kökler dişin uzun aksına paralel olacak şekilde ayrıldı. Daha sonra, her kök kesitinin orta ve apikal 1/3 bölgelerinde meydana gelen yüzey pürüzlülük değerleri profilometer kullanılarak ölçüldü ve SEM analizi uygulandı. Elde edilen veriler, iki yönlü varyans analizi (ANOVA) ve Tukey post-hoc analiz testleri kullanılarak analiz edilmiştir.

***Bulgular:*** Orta ve apikal 1/3 yüzeylerinden elde edilen ölçüm sonuçlarına göre; istatistiksel olarak en yüksek pürüzlülük değeri Nd:YAG lazer sonrası tespit edilmesine rağmen ($p<0,05$), istatistiksel olarak en düşük değer Er:YAG lazer ışınlama sonrasında tespit edildi ($p<0,05$).

***Sonuçlar:*** Bu çalışmanın ışığında, tüm lazer sistemleri önemli ölçüde yüzey pürüzlülüğüne neden oldular. Bu nedenle, lazer sistemleri insan kök kanallarında dikkatle uygulanmalıdır.

***Anahtar Kelimeler:*** Lazer; Endodonti; Nd:YAG; Er:YAG; SEM.



a drrecaizan@hotmail.com https://orcid.org/0000-0002-2781-355X
b topcuogluhs@hotmail.com https://orcid.org/0000-0001-5944-9740
c hubbezoglu@gmail.com https://orcid.org/0000-0001-8984-9286
d dt_demmet@hotmail.com https://orcid.org/0000-0002-7532-4785
e 2017105068@cumhuriyet.edu.tr https://orcid.org/0000-0002-9095-2165

*How to Cite:* Zan R, Topçuoğlu HS, Hubbezoğu İ, Demet Altunbaş D, Demir AŞ. (2023) The Roughening Effects of Er:YAG, Nd:YAG, and KTP Laser Systems on Root Dentin Surface, Cumhuriyet Dental Journal, 26(1):63-68.

## Introduction

Success in endodontic treatments depends on many factors. One of the most important of these factors is root canal disinfection. For this purpose, many methods and materials have been tried and brought to the world of endodontics. One of the most important pieces of equipment that advanced technology has brought to dentistry in recent years is lasers.[1,2] The word laser is the short description of "light amplification by stimulated emission of radiation". This word is a description of each laser tool-specific feature and this definition is the basis for the future use of lasers in dentistry, especially in endodontics. Laser has been preferred because of the following reasons: light hand tool, ease of use, controllable and well-focused characteristics of the beam, ease of working comfortably in every corner of the mouth, ease of sterilization of parts that contact with the patient, implementation of the system in a cheap and time-consuming way.[3,4] The common purpose of using different types of lasers is to provide effective disinfection against bacteria, viruses, fungi, and spores. In this context, the use of lasers in the field of endodontics has recently gained popularity.[5] The most used lasers in this field are Er:YAG, Nd:YAG, Diode, and KTP lasers. Different laser systems, such as argon lasers, diode lasers, HeNe lasers, Nd:YAG lasers, Ho:YAG lasers, Er:YAG lasers, and $CO_2$ lasers, are confirmed for use in dental practice. Different laser systems have different usage areas according to the target tissue and the qualifications of the laser system.[3,4] Diode lasers are efficient in endodontic disinfection procedures due to the affinity of their wavelengths for bacterial cells. Er:YAG and $CO_2$ lasers were found to be the most effective laser systems in the manner of cavity opening. These laser systems allow for working with less energy in carious tissue than in solid hard tooth tissue. Thus, with the power-adjusted laser system, it is possible to remove only rotten tissue without making any changes to healthy tissue. On the other hand, KTP (potassium-titanyl-phosphate) lasers are the most efficient both for surgical and bleaching procedures.[6,7] However, there has not been enough study on the mechanical effects of these laser systems on root canals. Based on this shortcoming, our study aims to evaluate and compare the roughening ability of different laser systems on the middle and apical tripartite regions of the root canal.

## Materials and Methods

### *Teeth Samples*

In the present study, periapical radiographs of 60 extracted teeth in the mesiodistal and buccolingual directions were taken. The teeth were extracted due to periodontal disease, orthodontic, or prosthetic treatment planning. The mandibular premolar human teeth with a single root and single canal were used. Debris and soft tissue remnants on the tooth surfaces were removed and all teeth were stored in 0.1% thymol at 9°C until use.

### *Root Canal Preparation*

The crowns of the teeth were removed with a diamond fissure bur (Diatech Dental AG, Heerbrugg, Switzerland) under water-cooling with a root length of approximately 14-16 mm to standardize the working lengths. Working length was determined by retracting 1 mm from the distance at which the #10 K-file was seen from the apical foramen. The teeth were prepared using the Protaper Next Nickel-Titanium (Ni-Ti) (PTN, Dentsply Maillefer, Ballaigues, Switzerland) rotary file system. 2 ml 5.25% NaOCl (Imicryl Dental, Konya, Turkey) was used at each file change during root canal preparation, 10 ml 17% EDTA (Imicryl Dental, Konya, Turkey) was used when preparation is complete and followed by 10 ml 2.5% of NaOCl. As final irrigation, the root canals were irrigated with 10 ml of distilled water and dried with paper points. All irrigation protocols were performed using with endo activator to eliminate the whole smear layer.

### *Experimental Groups*

### *Laser Irradiation*

Teeth were randomly divided into 3 main groups with different laser systems as Er:YAG, Nd:YAG, and KTP lasers.

***Nd:YAG and KTP Group:*** Root canal surfaces were irradiated using an Nd:YAG (Smarty A10, DEKA M.E.L.A. SRL, Italy) and a KTP (SmartLite D, DEKA M.E.L.A. SRL, Italy) laser systems. The parameters used were 100 mJ, 15 Hz, and 1.5 W with repeated pulse mode. A 200 µm fiber optic energy delivery system was started with spiral movements 1 mm above the apex and applied for 10 seconds towards the coronal, and 15 seconds waited after each irradiation. This procedure was repeated 12 times (A total time of 5 min.).

***Er:YAG Group:*** ER:YAG (Smarty 2940D, DEKA M.E.L.A. SRL, Italy) laser systems' parameters used were 100 mJ, 15 Hz, and 1.5 W. The sapphire endodontic tip was inserted 1 mm short of the apex, the laser was continuously irradiated from the apical to the coronal ends in slow and circling movements (approximately 3 mm/s) it is scanned for 5 min.

### *Roughness Measurement Procedure*

All tooth roots were divided into two parts parallel to the long axis of the tooth in the buccolingual direction and embedded in acrylic resin. Surface roughness values occurring during the middle, and apical 1/3 regions of each root section were determined with a digital hardness tester SJ 301 (Mitutoyo, Tokyo, Japan) Ra (arithmetic mean of roughness -µm) before and after preparation. SEM analyses were performed on root canal surfaces after laser applications (Figures 1, 2, and 3). In addition, graphs of the roughening of the root canals after laser applications were obtained (Figures 4, 5, and 6). The obtained data were analysed using one-way analysis of variance (ANOVA) and Tukey post-hoc analysis tests.

## Results

The mean values (standard deviation) of all groups together with their statistical comparisons obtained for the roughness effect of 3 different laser systems into the

internal surface of the root canal are presented in Table 1. According to the measurement results obtained from the middle and apical 1/3 surfaces; although statistically the highest roughness values were detected after Nd:YAG laser ($p<0.05$), statistically the lowest values were detected after Er:YAG laser irradiation ($p<0.05$).

## Discussion

Root canal disinfection plays a very critical role in endodontic treatment. Endodontic disinfection has been the main subject of many classic studies in dentistry. Thus, root canal cleaning procedures have been studied by many researchers up to the present. Residual bacteria is one of the greatest challenges in endodontic disinfection. It's known that the complete elimination of bacteria in root canals is not possible yet it can be decreased to a level that can lead to the success of endodontic therapy.[7] Different root canal disinfection techniques have been used in endodontic practice.[1,8] Recently, researchers have shown an increased interest in laser implications in dental practice as well as endodontic practice.[9] Therefore, the present study was designed to determine the effect of the roughening ability of different laser systems including Er:YAG, Nd:YAG, and KTP laser systems on the middle and apical third of the root dentin by using a scanning electron microscope (SEM). The present study has shown that Nd:YAG laser exhibited the highest roughness value on the root dentin surface and the Er:YAG laser irradiation showed statistically the lowest roughness value on the root dentin surface. This finding was also reported by Pirnat *et al.*[8] as they conducted that Nd:YAG laser cause more reduction to particular bacteria and provided better disinfection compared to the diode laser in their study. Another highlight in increasing the antimicrobial effects of Nd:YAG lasers in especially deeper layers.[10] These studies support evidence from previous observations.[7,11] The high-value results can be on account of the intermittently produced radiation through a pulsed energy input. In Nd:YAG laser systems, each pulse has a very short and high energy peak, up to 1000 W, however, the average energy output is much lower. In addition, the 1064 nm radiation emitted by the Nd:YAG laser is primarily absorbed by dark pigments. The use of black dye was therefore used in several studies to enhance the effect of lasing.[9] Sapphire tips were chosen in the previous study because of their high transmission for NIR wavelengths.[8] Romanos *et al.*[12] have compared the effectiveness of two laser tips (sapphire chisel and radial firing period) on temperature change after laser irradiation; they concluded that sapphire was more advantageous when compared to the other. It's also remarkable that laser systems have photothermal effects as well as photochemical effects. An important finding about Nd:YAG lasers are their substantial photothermal properties. Thus, attention is required when studying with Nd:YAG lasers because of the possible damage to the dentin surface and periradicular tissues. Ramsköld *et al.* conducted that dentin and water have different heat absorbing and conducting levels and they noted that water requires nearly four times more energy than dentin to raise the temperature to the same degree. In conclusion, thy reported that dry and wet root canals absorb energy differently.[9] This is important according to the disinfection mechanism of Nd:YAG lasers because heating the microenvironment is the main approach to removing bacteria in root canals.[5] This outcome is contrary to that of Meire *et al.* who found that Er:YAG lasers have a better potential in disinfecting the root canals. They also noted that Nd:YAG lasers have enhanced penetration ability in dentinal tubules and have a better potential in reaching these areas in root canals.[5] In addition, irradiance is effective in the antimicrobial property.[5] To our knowledge, there are limited studies about laser roughening effects on root canal dentin to compare with the present study. Following the present results, previous studies[13] have demonstrated that Nd:YAG lasers induced the furthest mechanical changes on both dentin and enamel surface. Nevertheless, they reported that Nd:YAG laser caused changes in mineral substance on both surfaces.[13] Supporting of present study' results, Nd:YAG lasers cause a meaningful roughness on the dentinal surface.[14]

Araki *et al.*[15] demonstrated the efficacy of Er:YAG laser irradiation on the microbiological apical biofilm and they reported that the Er:YAG laser caused a roughening effect on the dentin surface. Additionally, it was reported in another study that, there can be a difference in surface roughness between each laser system due to uncertain reasons. Furthermore, differences can be an account of the properties of laser devices and the density of the energy as well as the differences in evaluation techniques.[13] Shoji *et al.* reported that applying Er:YAG laser on root surfaces caused open dentinal tubules and this technique provided cleaner canals compared to the other techniques. They also reported that the reason for the cleanliness of the root canals is that the Er:YAG laser is a near-infrared laser that conduces to photo vaporization property which breaks down the dental tissue because of its emission.[16] In another study, Er:YAG laser technique was compared to traditional techniques on root surface roughening and conducted that the laser technique caused a meaningful roughness without damaging underlying tissues. This might be because the laser technique opens dentinal tubules and perform as an etching agent.[17] Also, Armengol *et al.*[18] proved that Er:YAG laser caused greater changes and roughness on the root canal dentine surface. As a result of these studies that supported the present study's result Er:YAG laser has a notable roughening effect on root canals. In addition, although that laser type may cause less roughening effect than other tested lasers, it can be preferred during root canal treatments.

Further optimization of irradiation parameters should improve the overall success rate of laser-assisted endodontic treatment. A recent study[8], targeted analysing the potential photodamage effect on a sub-cellular level, and aimed at analysing the spot and area temperature rises with the help of thermal imaging in sound and infected dentin could help to optimize the already established procedure.

In light of the present study, all types of laser systems provided remarkably applicable effects on root canal inner dentin walls. Specially, these laser-type roughening approaches used in the present study may prefer to increase the adhesion of adhesive cement in prosthodontic practices and also between dentin wall and canal filling materials in endodontic treatments. Considering these advantages, either prosthodontic or endodontic treatments may become more successful in the long term. However, SEM observation showed that laser irradiation produces mechanical modifications or root dentin surface, which can provide a disinfection effect. Previous research has shown that human root canal dentin can be altered by Er:YAG, Nd:YAG, and KTP laser systems. Since this laser radiation causes mechanical changes on the root dentin surface, a better disinfection procedure can be obtained.

## Conclusion

Within the limitations of the previous study, our results support the use of laser systems on dentin surface roughening when carefully used. However, more extensive clinical studies are needed to determine the extent of any benefits gained by laser roughening.

**Table 1.** Mean (Standard Deviation) together with their statistical comparisons, were obtained from all groups.

| Groups | Medium Roughness Mean (SD) | Apical Roughness Mean (SD) |
|---|---|---|
| *Er:YAG laser* | 0.549 (0.240)$^{A,a,b}$ | 0.214 (0.240)$^{A,d,e}$ |
| *Nd:YAG laser* | 1.161 (0.374)$^{B,a,c}$ | 0.669 (0.193)$^{B,d,f}$ |
| *KTP laser* | 0.768 (0.147)$^{C,b,c}$ | 0.415 (0.114)$^{C,e,f}$ |

By the two-way ANOVA, F = 44.329; p = 0.000 (p < 0.05).
Capital letters indicate the difference between regions of the root, and lowercase letters the statistical difference between lasers. Value with the same superscript letter indicates a statistically significantly different at p > 0.05 by Tukey's Test.

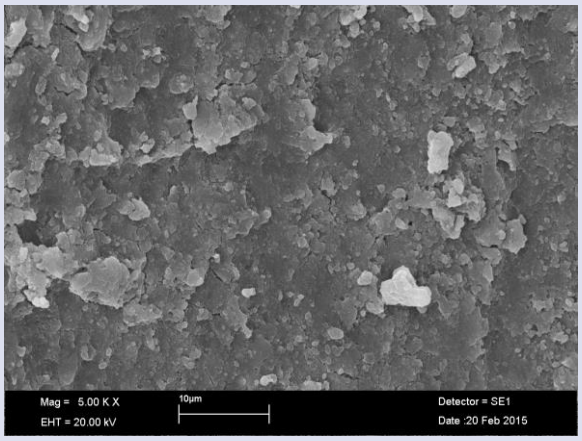



*Figure 1. SEM micrograph of dentin surface treated with 3.5 W laser in Group Nd:YAG (original magnification ×2.50 k).*

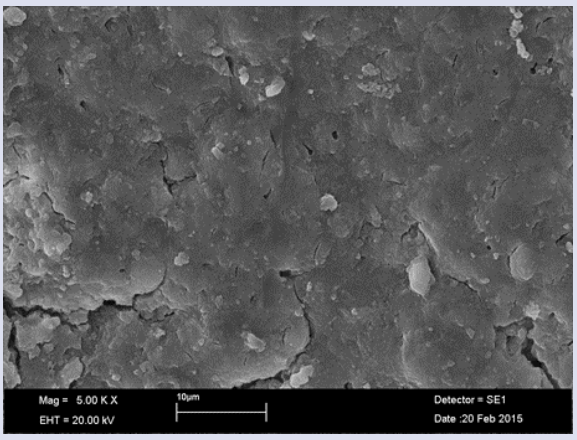



*Figure 2. SEM micrograph of dentin surface treated with 3.5 W laser in Group Er:YAG (original magnification ×2.50 k).*

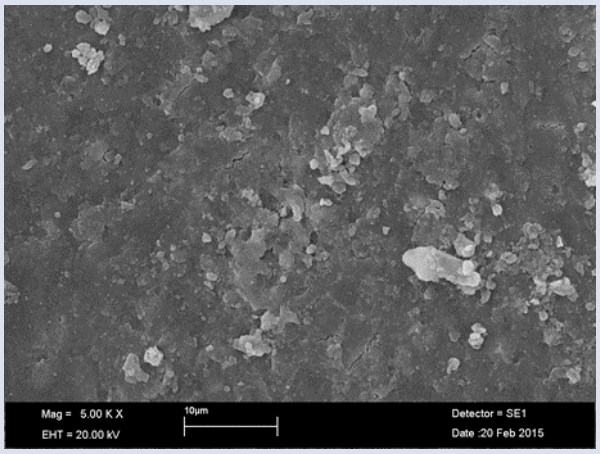



*Figure 3. SEM micrograph of dentin surface treated with 3.5 W laser in Group KTP (original magnification ×2.50 k).*

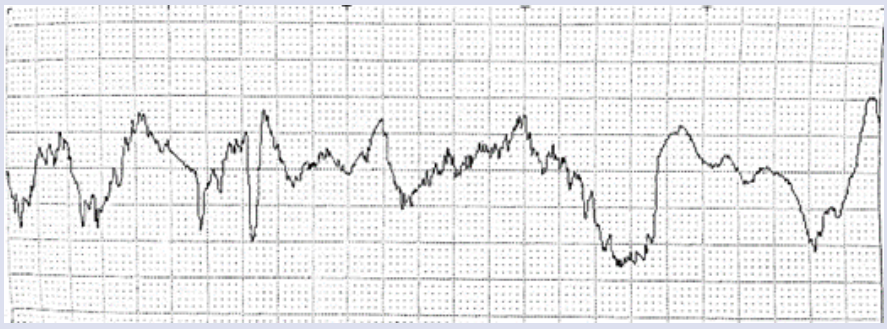


*Figure 4. Root dentin roughening graphic of Nd:YAG laser.*

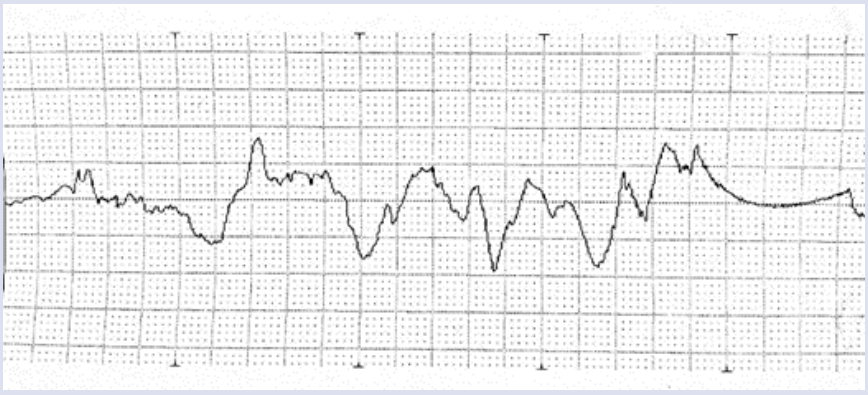


*Figure 5. Root dentin roughening graphic of Er:YAG laser.*

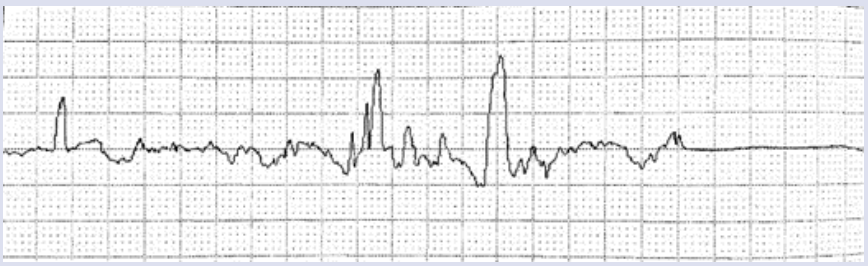


*Figure 6. Root dentin roughening graphic of KTP laser.*

## References


1. Jezeršek M, Lukač N, Lukač M, Tenyi A, Olivi G, Fidler A. Measurement of Pressures Generated in Root Canal during Er:YAG Laser-Activated Irrigation. Photobiomodulation, Photomedicine, Laser Surg 2020;38:625–631.
2. Phi R, Salimbeni R, Vannini M, Barone R, Clauser C. Laser Dentistry: A New Application of Excimer Laser in Root Canal Therapy. Lasers Surg Med 1989;9:352–357.
3. Tunaç AT, Şen BH. Endodontıd e lazer kullanimi 2010.
4. Sungurtekin E, Bani M, Öztaş N.. Mîne pürüzlendır me yöntemlerı. GÜ Diş Hė k Fak Derg 2009;26:189–194.
5. Meire MA, Coenye T, Nelis HJ, De Moor RJG. In vitro inactivation of endodontic pathogens with Nd:YAG and Er:YAG lasers. Lasers Med Sci 2012;27:695–701.
6. Akcay M, Arslan H, Mese M, Durmus N, Capar ID. Effect of photon-initiated photoacoustic streaming, passive ultrasonic, and sonic irrigation techniques on dentinal tubule penetration of irrigation solution: a confocal microscopic study. Clin Oral Investig 2017;21:2205–2212.
7. Stabholz A, Sahar-Helft S, Moshonov J. Lasers in endodontics. Dent Clin North Am 2004;48:809–832.
8. Pirnat S, Lukac M, Ihan A. Study of the direct bactericidal effect of Nd:YAG and diode laser parameters used in endodontics on pigmented and nonpigmented bacteria. Lasers Med Sci 2011;26:755–761.
9. Ramsköld LO, Fong CD, Strömberg T. Thermal effects and antibacterial properties of energy levels required to sterilize stained root canals with an Nd:YAG laser. J Endod 1997;23:96–100.
10. Murray BE. The life and times of the Enterococcus. Clin Microbiol Rev 1990;3:46–65.
11. Folwaczny M, Mehl A, Jordan C, Hickel R. Antibacterial Effects of Pulsed Nd : YAG Laser Root Canals. J Endod 2002;28:24–29.
12. Romanos G, Montanaro N, Sacks D, Miller R, Javed F, CalvoGuirado J, et al. Various Tip Applications and Temperature Changes of Er,Cr:YSGG-Laser Irradiated Implants In Vitro. Int J Periodontics Restorative Dent 2017;37:387–392.
13. Sazak H, Türkmen C, Günday M. Effects of Nd: YAG laser, airabrasion and acid-etching on human enamel and dentin. Oper Dent 2001;26:476–481.
14. Hossain M, Nakamura Y, Yamada Y, Suzuki N, Murakami Y, Matsumoto K. Analysis of Surface Roughness of Enamel and Dentin after Er,Cr:YSGG Laser Irradiation. Https://HomeLiebertpubCom/Pho 2004;19:297–303.
15. Araki ÂT, Ibraki Y, Kawakami T, Luiz Lage-Marques J. Er:YAG Laser Irradiation of the Microbiological Apical Biofilm. Braz Dent J 2006;17:296-299.
16. Shoji S, Hariu H, Horiuchi H. Canal enlargement by Er:YAG Laser using a cone-shaped irradiation tip. J Endod 2000;26:454–458.
17. Hossain M, Nakamura Y, Yamada Y, Suzuki N, Murakami Y, Matsumoto K. Analysis of surface roughness of enamel and dentin after Er,Cr:YSGG laser irradiation. J Clin Laser Med Surg 2001;19:297–303.
18. Armengol V, Laboux O , Weiss P, Jean A, Hannel H. Effects of Er:YAG and Nd:YAP Laser Irradiation on the Surface Roughness and Free Surface Energy of Enamel and Dentin: An In Vitro Study. Oper Dent 2003;28:67–74.

Cumhuriyet Dental Journal, 26(1): 69-76, 2023
DOI: https://doi.org/10.7126/cumudj. 1246959

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 | Available online, ISSN: 1302-5805 e-ISSN: 2146-2852 | Publisher: Sivas Cumhuriyet Üniversitesi

# *Knowledge, Attitudes and Practices of Dentists Regarding Pharmacovigilance and Reporting of Adverse Drug Reactions in Northwestern Turkiye: A Cross-Sectional Study*

***Gizem Colakoglu[1-a*], Isil Kaya Buyukbayram[2-b]***

[1] *Department of Dentomaxillofacial Radiology, Faculty of Dentistry, Istanbul Aydin University, Istanbul, Türkiye.*
[2] *Department of Endodontics, Faculty of Dentistry, Istanbul Aydin University, Istanbul, Türkiye.*
**Corresponding author*

**Research Article**

*History*

*Received: 03/02/2023*
*Accepted: 13/02/2023*

**ABSTRACT**

***Objectives:*** The drugs commonly used/prescribed by dentists/physicians or consumed by patients may cause adverse drug reactions (ADRs). Therefore, the possibility of dentists to encounter an ADR during their professional lives cannot be underestimated and the contribution of dentists to pharmacovigilance systems by notifying spontaneous ADR reports play an important role in the early detection and prevention of ADRs. This study aimed to assess the knowledge, attitudes and practices of dentists regarding pharmacovigilance and ADR reporting.

***Materials and Methods:*** A questionnaire with 30 questions evaluating knowledge, attitudes and practices of pharmacovigilance and ADR reporting among general dentists (GDs) and specialist dentists (SDs) was distributed electronically in northwestern region of Turkey. Data were statistically analyzed ($p < 0.05$).

***Results:*** Most of the participants were able to define the terms of pharmacovigilance (64.7%), ADR (74.9%) and side-effect (58.1%). SDs were significantly more aware of ADRs related to the drugs used/prescribed by dentists/physicians and other drugs consumed by patients than GDs. Additionally, awareness of ADRs regarding these drugs was significantly higher among participants with ≤12 years of experience ($p<0.05$). Only 2.8% of participants (4 GDs, 6 SDs) reported an ADR in their professional lives. However, 52.5% of participants had encountered an oral mucosal ADR during their professional lives, which was statistically higher in the group of SDs and participants with >12 years of experience ($p<0.05$).

***Conclusions:*** The role of dentists in the diagnosis and reporting of ADRs should not be underestimated since they are an integral part of the healthcare system. The contribution of both GDs and SDs to the ADR reporting system needs to be improved in Turkey. Additionally, ADR reporting should be integrated into daily practices of dentists.

***Keywords:*** Adverse Drug Reaction; Dentists; Pharmacovigilance.

# Türkiye'nin Kuzeybatısındaki Diş Hekimlerinin Farmakovijilans ve Advers İlaç Reaksiyonlarının Raporlanmasına İlişkin Bilgi, Tutum ve Uygulamaları: Kesitsel Bir Çalışma

*Süreç*

*Geliş: 03/02/2023*
*Kabul: 13/02/2023*

**ÖZ**

***Amaç:*** Diş hekimleri/doktorlar tarafından kullanılan/reçete edilen ya da hastaların aldığı ilaçlar, advers ilaç reaksiyonlarına (AİR) yol açabilmektedirler. Bu yüzden, diş hekimlerinin profesyonel hayatları boyunca AİR ile karşılaşma olasılıkları göz ardı edilemez ve diş hekimlerinin AİR raporlarını spontan bildirimleri ile farmakovijilans sistemlerine katkıları, AİR'nin erken tespiti ve önlenmesinde önemli rol oynamaktadır. Bu çalışma, diş hekimlerinin farmakovijilans ve AİR raporlaması hakkında bilgi, tutum ve uygulamalarının değerlendirilmesini amaçlamaktadır.

***Gereç ve Yöntemler:*** Türkiye'nin kuzeybatı bölgesinde genel diş hekimleri (GDH) ve uzman diş hekimleri (UDH) arasında, farmakovijilans ve AİR raporlaması hakkında bilgi, tutum ve uygulamalarını değerlendiren 30 soruluk bir anket, elektronik olarak dağıtılmıştır. Elde edilen veriler istatistiksel olarak analiz edilmiştir ($p<0,05$).

***Bulgular:*** Katılımcıların büyük çoğunluğu, farmakovijilans (%64,7), AİR (%74,9) ve yan etki (%58,1) terimlerini tanımlayabilmiştir. UDH'ler, diş hekimleri/doktorlar tarafından kullanılan/reçete edilen ilaçlar ya da hastaların aldığı diğer ilaçlarla ilgili AİR'lerin, GDH'lere göre önemli ölçüde daha fazla farkındaydı. Ayrıca, bu ilaçlarla ilgili AİR farkındalığı, ≤12 yıllık deneyime sahip katılımcılar arasında anlamlı olarak daha yüksekti ($p<0,05$). Katılımcıların yalnızca %2,8'i (4 GDH, 6 UDH) profesyonel hayatlarında bir AİR bildirmiştir. Ancak, katılımcıların %52,5'i profesyonel hayatlarında oral mukozal AİR ile karşılaşmışlardır; bu oran UDH grubunda ve >12 yıllık deneyime sahip katılımcılarda istatistiksel olarak daha yüksekti ($p<0,05$).

***Sonuçlar:*** AİR'lerin teşhisinde ve raporlanmasında diş hekimlerinin rolü, sağlık sisteminin ayrılmaz bir parçası oldukları için küçümsenmemelidir. Türkiye'de hem GDH'lerin hem de UDH'lerin AİR raporlama sistemine katkılarının iyileştirilmesi gerekmektedir. Ek olarak, AİR raporlaması diş hekimlerinin günlük pratiklerine entegre edilmelidir.

***Anahtar Kelimeler:*** Advers Ilaç Reaksiyonu; Diş Hekimleri; Farmakovijilans.



a gizemcolakoglu@aydin.edu.tr https://orcid.org/0000-0002-9471-9993 b isilkayabuyukbayram@aydin.edu.tr https://orcid.org/0000-0002-3118-9665

*How to Cite:* Çolakoğlu G, Kaya Büyükbayram I. (2023) Knowledge, Attitudes and Practices of Dentists Regarding Pharmacovigilance and Reporting of Adverse Drug Reactions in Northwestern Turkiye: A Cross-Sectional Study, Cumhuriyet Dental Journal, 26(1):69-76.

## Introduction

The worldwide increase in drug consumption, including in Turkey, the use of over-the-counter drugs and/or herbal remedies in addition to prescribed drugs, and polypharmacy, especially among elderly patients, require dentists to be careful about potential adverse drug reactions (ADRs).[1] These reactions may develop due to the drugs commonly used/prescribed by dentists/physicians or consumed by patients.[2,3] The frequency of many drug-related oral reactions is not known precisely because of their subclinical course.[4] However, more than 200 drugs have been demonstrated to be involved in ADRs in oral tissues.[1] Furthermore, antibiotics and analgesics, which are prescribed routinely by dentists, are among the major causes of ADRs.[5] Despite the high possibility of encountering an ADR during routine dental practice, dentists' contributions to ADR reporting are reported to be less than 1%.[6]

The knowledge, attitudes and practices (KAP) of health care professionals (HPs) regarding ADRs and their contribution to pharmacovigilance (PV) systems by providing spontaneous ADR reports to competent authorities play an important role in the early detection and prevention of ADRs.[7-9]

Limited contributions of HPs to PV activities in Turkey were reported due to their scarce PV knowledge, similar to the findings of studies in other countries. Most of these studies have been predominantly focused on the KAP of physicians, nurses and pharmacists.[7,10-15] The possibility of both oral mucosal ADRs due to various drugs and ADRs due to used/prescribed drugs by dentists cannot be underestimated, and it is of the utmost importance to create awareness among dentists about the progression of PV in Turkey. Therefore, this study aimed to assess the KAP of dentists regarding PV and ADR reporting and its association with the demographic characteristics of dentists (sex, profession, and professional experience).

## Materials and Methods

The protocol of this study was approved by the Ethics Committee of Istanbul Aydin University (Protocol no: B.30.2.AYD.0.00.00-050.06.04/455). Between March 2021-September 2021, this cross-sectional study was conducted to evaluate the KAP regarding PV and ADR reporting among general dentists (GDs) and specialist dentists (SDs) working in the northwestern region of Turkey. The questionnaire was designed with the guidance of regulatory instructions and informative documents published on the website of the Turkish Pharmacovigilance Center (TUFAM) and previous reports.[3,4,16,17-19] The questionnaire consisted of 30 closed-ended multiple-choice questions (in some questions, multiple responses were allowed) and was subdivided into four sections:

1. Demographic characteristics of the participants (5 questions)
2. Assessment of the participants' knowledge about PV, ADRs and ADR reporting (8 questions)
3. Assessment of the participants' attitudes regarding ADRs and ADR reporting (5 questions)
4. Assessment of the participants' practices regarding ADRs and ADR reporting (12 questions)

The questionnaire was distributed to dentists electronically via the Istanbul Chamber of Dentists. The webpage opened with information outlining the aims of this study and an informed consent form. Only after approval of the form to voluntarily answer the questions was the participant directed to the question page. A total of 360 questionnaires were available for analysis.

The data were analyzed using the Statistical Package for the Social Sciences (SPSS, version 15.0; Armonk, NY: IBM Corp.) according to descriptive statistics. A chi-square test was performed to verify the differences between the groups. The level of significance was set to $p<0.05$.

## Results

A total of 170 GDs and 190 SDs aged between 23-72 years (37.0±9.8) participated in this study. The participants were divided into two groups of ≤12 years and >12 years, considering the median years of professional experience (Table 1).

### *Knowledge about PV, ADRs and ADR reporting*

Most of the dentists (71.4%) correctly defined ADR. Female participants (74.9%) seemed to be more knowledgeable about ADR than males (65.1%) ($p=0.049$). More than half of the dentists had knowledge of the terms "PV" and "side effect" (64.7% and 58.1%, respectively). There was no statistically significant difference between GDs and SDs regarding the previously mentioned terms ($p>0.05$). Dentists with ≤12 years of experience had significantly more knowledge about side effect ($p=0.002$).

Only 13.9% of the dentists know the time period to report ADRs after encountering them. The participants' responses were statistically nonsignificant regarding sex, profession, and professional experience ($p>0.05$).

Female dentists seemed to have greater knowledge about how to complete the ADR reporting forms than males ($p<0.05$). Compared to GDs, SDs indicated writing identity of the patient and the reporter in the form significantly more often ($p<0.05$).

The most well-known drugs commonly used/prescribed in dentistry that cause ADRs are listed in Table 2. Only 8.1% of the dentists did not know any of these drugs, which was statistically lower in the group of SDs ($p=0.04$). Awareness of ADRs regarding these drugs was significantly higher among participants with ≤12 years of experience than among participants with >12 years of experience ($p<0.05$). Moreover, the participants were asked "Which drugs cause an oral mucosal ADR?". GDs had significantly poorer knowledge about these drugs than SDs, which was also significant in the group of participants with > 12 years of experience compared to participants with ≤12 years of experience ($p<0.05$) (Table 3).

**Table 1:** The demographic characteristics of the dentists who participated in the study

| | | | n | % |
|---|---|---|---|---|
| **Gender** | | Female | 231 | 64.2 |
| | | Male | 129 | 35.8 |
| **Professional experience (years)** | | ≤12 | 199 | 55.3 |
| | | >12 | 161 | 44.7 |
| **Profession** | **GDs** | | 170 | 47.2 |
| | **SDs** | Maxillofacial Radiologist | 15 | 4.2 |
| | | Maxillofacial Surgeon | 24 | 6.7 |
| | | Endodontist | 18 | 5.0 |
| | | Orthodontist | 28 | 7.8 |
| | | Pedodontist | 25 | 6.9 |
| | | Periodontist | 25 | 6.9 |
| | | Prosthodontist | 37 | 10.3 |
| | | Restorative Dentistry | 18 | 5.0 |
| | | Total | 190 | 52.8 |
| **Institution** | | Faculty | 125 | 34.7 |
| | | Private practice | 34 | 9.4 |
| | | State hospital | 82 | 22.8 |
| | | Polyclinic/Private Hospital | 119 | 33.1 |

*GD,* General dentist; *SD,* Specialist dentist.

**Table 2:** The distribution of the commonly used/prescribed drugs in dentistry that cause ADRs

| Commonly drugs used/ prescribed in dentistry* | Gender | | | | | Profession | | | | | Professional experience | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Female | | Male | | p | GDs | | SDs | | p | ≤12 years | | >12 years | | p |
| | n | % | n | % | | n | % | n | % | | n | % | n | % | |
| **Local anesthetics** | 196 | 84.8 | 102 | 79.1 | 0.164 | 134 | 78.8 | 164 | 86.3 | 0.060 | 163 | 81.9 | 135 | 83.9 | 0.628 |
| **Analgesics** | 168 | 72.7 | 97 | 75.2 | 0.611 | 119 | 70.0 | 146 | 76.8 | 0.141 | 149 | 74.9 | 116 | 72.0 | 0.545 |
| **Antibiotics** | 202 | 87.4 | 115 | 89.1 | 0.633 | 148 | 87.1 | 169 | 88.9 | 0.581 | 173 | 86.9 | 144 | 89.4 | 0.466 |
| **Antifungals** | 119 | 51.5 | 60 | 46.5 | 0.363 | 64 | 37.6 | 115 | 60.5 | **< 0.001** | 115 | 57.8 | 64 | 39.8 | **0.001** |
| **Antiinflammatory mouthwashes** | 128 | 55.4 | 68 | 52.7 | 0.622 | 80 | 47.1 | 116 | 61.1 | **0.008** | 118 | 59.3 | 78 | 48.4 | **0.040** |
| **Sedatives/general anesthetics** | 164 | 71.0 | 74 | 57.4 | **0.009** | 94 | 55.3 | 144 | 75.8 | **< 0.001** | 145 | 72.9 | 93 | 57.8 | **0.003** |
| **Do not know** | 18 | 7.8 | 11 | 8.5 | 0.806 | 19 | 11.2 | 10 | 5.3 | **0.040** | 17 | 8.5 | 12 | 7.5 | 0.706 |

Chi-squared test; p<0.05

*More than one option could be selected

*ADR*, Adverse drug reaction; *GD,* General dentist; *SD,* Specialist dentist.

**Table 3:** The distribution of the commonly known drugs which are responsible for oral mucosal ADRs

| The drugs causing oral mucosal ADRs* | Gender | | | | | Profession | | | | | Professional experience | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Female | | Male | | p | GDs | | SDs | | p | ≤12 years | | >12 years | | p |
| | n | % | n | % | | n | % | n | % | | n | % | n | % | |
| **Local anesthetics** | 134 | 58.0 | 75 | 58.1 | 0.981 | 93 | 54.7 | 116 | 61.1 | 0.223 | 130 | 65.3 | 79 | 49.1 | **0.002** |
| **Antiinflammatory analgesics** | 84 | 36.4 | 49 | 38.0 | 0.760 | 56 | 32.9 | 77 | 40.5 | 0.137 | 77 | 38.7 | 56 | 34.8 | 0.445 |
| **Antiinflammatory mouthwashes** | 124 | 53.7 | 69 | 53.5 | 0.972 | 80 | 47.1 | 113 | 59.5 | **0.018** | 113 | 56.8 | 80 | 49.7 | 0.180 |
| **Antibiotics** | 148 | 64.1 | 91 | 70.5 | 0.212 | 112 | 65.9 | 127 | 66.8 | 0.847 | 137 | 68.8 | 102 | 63.4 | 0.273 |
| **Antifungals** | 99 | 42.9 | 67 | 51.9 | 0.097 | 66 | 38.8 | 100 | 52.6 | **0.009** | 100 | 50.3 | 66 | 41.0 | 0.080 |
| **Antidepressants** | 101 | 43.7 | 59 | 45.7 | 0.712 | 69 | 40.6 | 91 | 47.9 | 0.164 | 93 | 46.7 | 67 | 41.6 | 0.331 |
| **Antihypertensives** | 121 | 52.4 | 61 | 47.3 | 0.354 | 76 | 44.7 | 106 | 55.8 | **0.036** | 111 | 55.8 | 71 | 44.1 | **0.028** |
| **Anticonvulsants** | 111 | 48.1 | 58 | 45.0 | 0.573 | 64 | 37.6 | 105 | 55.3 | **0.001** | 108 | 54.3 | 61 | 37.9 | **0.002** |
| **Immunosuppressive drugs** | 142 | 61.5 | 84 | 65.1 | 0.493 | 99 | 58.2 | 127 | 66.8 | 0.092 | 132 | 66.3 | 94 | 58.4 | 0.121 |
| **Corticosteroids** | 119 | 51.5 | 67 | 51.9 | 1.000 | 88 | 51.8 | 98 | 51.6 | 0.972 | 115 | 57.8 | 71 | 44.1 | **0.010** |
| **Bisphosphonates/ Antiresorptives** | 137 | 59.3 | 86 | 66.7 | 0.168 | 99 | 58.2 | 124 | 65.3 | 0.170 | 131 | 65.8 | 92 | 57.1 | 0.091 |
| **Antiangiogenic drugs** | 59 | 25.5 | 34 | 26.4 | 0.865 | 28 | 16.5 | 65 | 34.2 | **< 0.001** | 65 | 32.7 | 28 | 17.4 | **0.001** |
| **Herbal drugs** | 57 | 24.7 | 36 | 27.9 | 0.502 | 30 | 17.6 | 63 | 33.2 | **0.001** | 55 | 27.6 | 38 | 23.6 | 0.384 |
| **Do not know** | 29 | 12.6 | 11 | 8.5 | 0.244 | 22 | 12.9 | 18 | 9.5 | 0.296 | 25 | 12.6 | 15 | 9.3 | 0.330 |

Chi-squared test; p<0.05.

*More than one option could be selected.

*ADR*, Adverse drug reaction; *GD,* General dentist; *SD,* Specialist dentist.

**Table 4:** The distribution of discouraging reasons for reporting ADRs

| Reasons* | Gender | | | | | Profession | | | | | Professional experience | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Female | | Male | | p | GDs | | SDs | | p | ≤12 years | | >12 years | | p |
| | n | % | n | % | | n | % | n | % | | n | % | n | % | |
| Lack of time to report | 10 | 4.3 | 5 | 3.9 | 0.837 | 10 | 5.9 | 5 | 2.6 | 0.123 | 6 | 3.0 | 9 | 5.6 | 0.224 |
| Not knowing how and where to report | 51 | 22.1 | 16 | 12.4 | **0.024** | 37 | 21.8 | 30 | 15.8 | 0.146 | 30 | 15.1 | 37 | 23.0 | 0.055 |
| Not being sure whether it is an ADR or not | 20 | 8.7 | 9 | 7.0 | 0.574 | 17 | 10.0 | 12 | 6.3 | 0.200 | 11 | 5.5 | 18 | 11.2 | 0.050 |
| No need to report it since it is a common ADR | 27 | 11.7 | 14 | 10.9 | 0.811 | 19 | 11.2 | 22 | 11.6 | 0.904 | 18 | 9.0 | 23 | 14.3 | 0.120 |
| The idea of one single ADR report could not make a difference | 15 | 6.5 | 7 | 5.4 | 0.685 | 11 | 6.5 | 11 | 5.8 | 0.788 | 12 | 6.0 | 10 | 6.2 | 0.943 |
| Not having the knowledge or courage to discuss ADRs with my colleagues | 6 | 2.6 | 5 | 3.9 | 0.532 | 9 | 5.3 | 2 | 1.1 | **0.020** | 6 | 3.0 | 5 | 3.1 | 1.000 |
| Concerns about the negative impact on my professional life or the pharmaceutical company | 3 | 1.3 | 1 | 0.8 | 1.000 | 3 | 1.8 | 5 | 2.6 | 0.347 | 2 | 1.0 | 2 | 1.2 | 1.000 |
| Legal liability issues | 4 | 1.7 | 3 | 2.3 | 0.705 | 4 | 2.4 | 30 | 15.8 | 0.711 | 4 | 2.0 | 3 | 1.9 | 1.000 |

Chi-squared test; p<0.05.
*More than one option could be selected.
*ADR*, Adverse drug reaction; *GD,* General dentist; *SD,* Specialist dentist.

### *Attitudes regarding ADRs and ADR reporting*

The majority of the dentists (75%) accepted that spontaneous reporting of ADRs was necessary, which was significantly higher among participants with ≤12 years of experience (p<0.013). The reasons of the participants who stated that this was not necessary or were unsure about it are listed in Table 4.

Of the dentists, 59.7% stated that all suspected reactions should be reported. The other responses regarded ADRs associated with newly marketed drugs (49.2%), unexpected ADRs (43.9%), serious ADRs (43.1%) and well-defined ADRs (41.4%). The participants' responses were statistically nonsignificant regarding sex, profession and professional experience (p>0.05).

Most of the dentists preferred to consult with a physician (68.9%) and to discontinue the suspected drug (62.5%) in the suspicion of an oral mucosal ADR. The number of dentists who opted to inform the authorities was significantly higher in the group of male dentists and participants with ≤12 years of experience (p<0.05). GDs tended to hospitalize patients more frequently than SDs (p=0.034). Younger dentists opted to reduce the dose of the suspected drug, whereas older dentists opted to discontinue the suspected drug (p<0.05) (Table 5).

Among the dentists, only 5% approved the spontaneous reporting of ADRs and 86.4% thought that ADR reporting was a professional responsibility, followed by a professional obligation (37.2%) and voluntary action (13.9%). The participants' responses were statistically nonsignificant regarding sex, profession, and professional experience (p>0.05).

### *Practices regarding ADRs and ADR reporting*

Only 2.8% of dentists (4 GDs, 6 SDs) had reported an ADR in their professional lives. The majority of the reports were made to the pharmacovigilance contact person (PCP) of their institutions (50%), followed by the pharmacy (20%), Turkish Medicines and Medical Devices Agency (10%), TUFAM (10%) and the pharmaceutical company (10%).

Of the dentists, 52.5% had encountered an oral mucosal ADR during their professional lives, which was statistically higher in the group of SDs and participants with >12 years of experience (p<0.05). The frequencies of ADRs were "once or twice during their professional lives" (36.5%), "once a year" (29.1%), "once to ten times a year" (29.6%) and "more than ten times a year" (4.8%). Among the participants, 34.7% had never diagnosed an oral mucosal ADR, whereas 12.8% were unsure about this.

Gingival overgrowth (63.6%) was the most frequently diagnosed oral mucosal ADR. Male dentists seemed to diagnose oral mucosal ADRs more often than females (p<0.05). Dentists with >12 years of experience detected significantly more ADRs in the oral mucosa (p<0.05) (Table 6).

The dentists were asked whether they asked about the patient's ADR history during anamnesis or before prescribing a drug. Compared to GDs, SDs were significantly more likely to ask about and record all the drugs, including herbal drugs (78.2% and 92.6%, respectively) and the patient's ADR history (64.1% and 73.2%, respectively) (p<0.05). Additionally, female dentists had a relatively higher rate of recording the patient's ADR history than males (90.5% and 81.4%, respectively) (p=0.002). The majority of the dentists prescribed any drug by taking into consideration the patient's ADR history (82.8%) or the possibility of ADRs, especially for elderly patients or patients with polypharmacy (82.5%). The participants' responses were statistically nonsignificant regarding professional experience (p>0.05).

Among the dentists, 50.3% had received training regarding ADRs during their education or professional lives, which was statistically higher among participants with ≤12 years of experience (p=0.002). Training regarding ADRs

occurred mostly in undergraduate education (79.5%), followed by postgraduate education (8.1%), conferences/continuing education courses with credits (7.6%), congresses (2.7%) and specialization exam prep courses (2.2%). Older dentists learned about ADRs mostly in postgraduate education (p=0.001).

## Discussion

This study's main findings revealed that the knowledge and perspectives of both GDs and SDs regarding PV and ADR reporting are unsatisfactory. Previous studies highlighted the poor knowledge of PV and ADRs among HPs.[7,8,10-14,16-18,20-22] In a study of dental research assistants in Turkey, the majority of the participants were unable to define PV (60%) and ADR (80%).[8] However, in this study, the majority of the participants were able to define these terms (64.7%; 71.4%). This difference may be due to the type of questions used in the studies.[8] Nevertheless, 17.5% of the participants mixed the terms "ADR" and "side effect" in this study, which was similar to a recent study among HPs that included dentists (22.7%).[14]

Recent Turkish studies demonstrated that most dentists had never seen or experienced any ADR before.[8,21] In contrast to these studies, the rate of dentists who had never diagnosed an ADR was low (34.7%) in this study, which was similar to that in Khan *et al.'s*[17] study (34.4%). Furthermore, 52.5% of the dentists, most of whom were SDs and participants with >12 years of experience, had encountered an oral mucosal ADR during their professional lives in this study. Unfortunately, the reporting rate in this study was too low (2.8%) compared to that in the aforementioned study (13.7%).[17] This poor reporting level was similar to that in previous studies.[18,21,22] Torwane *et al.*[18] noted a large gap between ADRs experienced (52.29%) and ADRs reported (6.12%) by HPs, especially among dentists, which was confirmed by the present study (52.5% and 2.8%, respectively). Additionally, the frequencies of ADRs experienced in a year in this study were remarkable at 29.1% for once a year and 34.4% for more than once a year. These findings are a matter of great concern for dentists and indicate the need for immediate attention to improve the contribution of dentists to ADR identification and reporting.

The findings of this study showed that the rate of dentists who experienced oral mucosal ADRs in clinical practice cannot be underestimated. The top five oral mucosal ADRs diagnosed by dentists in this study were gingival overgrowth (63.6%), discoloration of teeth (46.7%), xerostomia (40.8%), oral candidosis (30.3%), taste alterations (28.9%) and oral mucosal pigmentation (28.1%).

The TUFAM is the main contact point for the spontaneous reporting of ADRs by HPs in Turkey. However, dentists working in the hospital can also forward ADR reports to the TUFAM through the PCP. Only one SD reported ADR to the TUFAM in this study. The PCP of the institution was the most frequently preferred contact by dentists to report ADRs likewise in a previous Turkish study of physicians/nurses, in which only 30% of the participants were aware of the TUFAM.[16] These findings showed the lack of knowledge of dentists on ADR reporting to the TUFAM as well as that of physicians and nurses in Turkey.[12,16] Moreover, it is recommended to report an ADR within 15 days after encountering it, which was known only by 13.9% of the dentists in this study.

The TUFAM manages the monitoring and assessment of national ADR reports via an online notification form. First, the identity of the patient and the reporter must be determined in the form for validation of the report. Almost half of the dentists were not willing to provide the identity of the reporter, which was significantly lower among SDs in this study. However, the majority of the dentists were well informed about how to fill out this form.

According to current regulations, all HPs must be actively involved in PV activities within the context of their practices as a professional responsibility. Most of the dentists (86.4%) in this study agreed that reporting ADRs is a professional responsibility rather than a professional obligation (37.2%), which was similar to the findings of a recent study among dentists (89%).[19] Furthermore, only 5% of dentists participated in spontaneous reporting, although being the cornerstone of PV.[23]

Since underreporting is a global problem, the reasons dentists do not report ADRs are multifactorial and are also similar to those in other studies in the literature.[6,16-19,23] Identifying these factors will help authorities develop a specific strategy targeted at the main problem since attitudes are potentially modifiable variables.[24] Every ADR submitted to the system will help to improve patient safety and spontaneous reporting of ADRs. Furthermore, concerns about not having the knowledge or courage to discuss ADRs with their colleagues, which was significantly higher among GDs, and difficulty in deciding whether it's an ADR or not indicate a lack of training among dentists in identifying ADRs.

Regarding the responses about which ADRs should be reported, dentists were unaware of the risk of ADRs and the importance of their contribution to the detection of these risks. Indeed, the diagnosis and identification of osteochemonecrosis of jaw due to the ADRs of bisphosphonates through ADR reporting during the postmarketing phase of these drugs have been an important contribution of dentists that influenced the dental and medical management of the patients currently treated with these drugs.[25]

During their routine practice, it is the responsibility of dentists to thoroughly check and record the general health and medication history of patients and to update the history at every visit.[6] In a recent study, 60% of dental research assistants stated that they asked about the patient's drug history when interacting with a patient for the first time.[8] Similarly, the majority of the participants in this study indicated that they asked about and recorded all the drugs, including herbal drugs, and the patient's ADR history. Moreover, they were cautious about prescribing a drug to elderly patients and patients with polypharmacy or with an ADR history.

**Table 5:** The attitudes of the dentists in the suspicion of an oral mucosal ADR

| Attitudes of the dentists* | Gender | | | | | Profession | | | | | Professional experience | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Female | | Male | | p | GDs | | SDs | | p | ≤12 years | | >12 years | | p |
| | n | % | n | % | | n | % | n | % | | n | % | n | % | |
| To follow up the patient without doing anything | 17 | 7.4 | 8 | 6.2 | 0.679 | 11 | 6.5 | 14 | 7.4 | 0.738 | 11 | 5.5 | 14 | 8.7 | 0.240 |
| To follow up the patient after reducing the dose of the suspected drug | 49 | 21.2 | 19 | 14.7 | 0.132 | 30 | 17.6 | 38 | 20.0 | 0.569 | 47 | 23.6 | 21 | 13.0 | **0.011** |
| To discontinue the suspected drug if it's possible | 138 | 59.7 | 87 | 67.4 | 0.148 | 104 | 61.2 | 121 | 63.7 | 0.624 | 113 | 56.8 | 112 | 69.6 | **0.013** |
| To give an alternative drug | 87 | 37.7 | 47 | 36.4 | 0.817 | 63 | 37.1 | 71 | 37.4 | 0.952 | 80 | 40.2 | 54 | 33.5 | 0.194 |
| To hospitalize the patient | 46 | 19.9 | 24 | 18.6 | 0.764 | 41 | 24.1 | 29 | 15.3 | **0.034** | 44 | 22.1 | 26 | 16.1 | 0.155 |
| To consult with a physician | 167 | 72.3 | 81 | 62.8 | 0.062 | 108 | 63.5 | 140 | 73.7 | **0.038** | 144 | 72.4 | 104 | 64.6 | 0.114 |
| To inform the authorities | 43 | 18.6 | 45 | 34.9 | **0.001** | 45 | 26.5 | 43 | 22.6 | 0.397 | 58 | 29.1 | 30 | 18.6 | **0.021** |
| Do not know | 11 | 4.8 | 8 | 6.2 | 0.558 | 14 | 8.2 | 5 | 2.6 | 0.018 | 11 | 5.5 | 8 | 5.0 | 0.814 |

Chi-squared test; p<0.05.
*More than one option could be selected.
*ADR*, Adverse drug reaction; *GD,* General dentist; *SD,* Specialist dentist.

**Table 6:** The distribution of commonly diagnosed ADRs in the oral mucosa, *Chi-squared test; p<0.05.*

| Oral mucosal ADRs* | Gender | | | | | Profession | | | | | Professional experience | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Female | | Male | | p | GDs | | SDs | | p | ≤12 years | | >12 years | | p |
| | n | % | n | % | | n | % | n | % | | n | % | n | % | |
| Gingival overgrowth | 149 | 64.5 | 80 | 62.0 | 0.638 | 100 | 58.8 | 129 | 67.9 | 0.074 | 127 | 63.8 | 102 | 63.4 | 0.927 |
| Discoloration of teeth | 105 | 45.5 | 63 | 48.8 | 0.537 | 84 | 49.4 | 84 | 44.2 | 0.323 | 100 | 50.3 | 68 | 42.2 | 0.130 |
| Xerestomia | 99 | 42.9 | 48 | 37.2 | 0.296 | 56 | 32.9 | 91 | 47.9 | **0.004** | 88 | 44.2 | 59 | 36.6 | 0.146 |
| Oral candidosis | 67 | 29.0 | 42 | 32.6 | 0.482 | 45 | 26.5 | 64 | 33.7 | 0.137 | 55 | 27.6 | 54 | 33.5 | 0.226 |
| Taste alterations | 59 | 25.5 | 45 | 34.9 | 0.061 | 50 | 29.4 | 54 | 28.4 | 0.836 | 51 | 25.6 | 53 | 32.9 | 0.129 |
| Oral mucosal pigmentation | 59 | 25.5 | 42 | 32.6 | 0.155 | 44 | 25.9 | 57 | 30.0 | 0.385 | 61 | 30.7 | 40 | 24.8 | 0.223 |
| Burning mouth syndrome | 53 | 22.9 | 39 | 30.2 | 0.128 | 43 | 25.3 | 49 | 25.8 | 0.914 | 39 | 19.6 | 53 | 32.9 | **0.004** |
| Oral ulcer | 39 | 16.9 | 42 | 32.6 | **0.001** | 45 | 26.5 | 36 | 18.9 | 0.088 | 42 | 21.1 | 39 | 24.2 | 0.481 |
| Mukositis | 44 | 19.0 | 30 | 23.3 | 0.343 | 33 | 19.4 | 41 | 21.6 | 0.611 | 33 | 16.6 | 41 | 25.5 | **0.038** |
| Bruxism | 42 | 18.2 | 21 | 16.3 | 0.649 | 28 | 16.5 | 35 | 18.4 | 0.627 | 42 | 21.1 | 21 | 13.0 | **0.045** |
| Hairy tongue | 36 | 15.6 | 21 | 16.3 | 0.863 | 25 | 14.7 | 32 | 16.8 | 0.579 | 31 | 15.6 | 26 | 16.1 | 0.883 |
| Lichenoid reaction | 32 | 13.9 | 19 | 14.7 | 0.819 | 18 | 10.6 | 33 | 17.4 | 0.066 | 26 | 13.1 | 25 | 15.5 | 0.505 |
| Chelitis | 29 | 12.6 | 18 | 14.0 | 0.706 | 18 | 10.6 | 29 | 15.3 | 0.189 | 19 | 9.5 | 28 | 17.4 | **0.028** |
| Hypersalivation | 28 | 12.1 | 17 | 13.2 | 0.771 | 21 | 12.4 | 24 | 12.6 | 0.936 | 27 | 13.6 | 18 | 11.2 | 0.496 |
| Paresthesia | 20 | 8.7 | 15 | 11.6 | 0.362 | 20 | 11.8 | 15 | 7.9 | 0.216 | 15 | 7.5 | 20 | 12.4 | 0.120 |
| Orofacial pain | 17 | 7.4 | 13 | 10.1 | 0.371 | 16 | 9.4 | 14 | 7.4 | 0.484 | 16 | 8.0 | 14 | 8.7 | 0.823 |
| Bullous reactions | 11 | 4.8 | 18 | 14.0 | **0.002** | 14 | 8.2 | 15 | 7.9 | 0.906 | 10 | 5.0 | 19 | 11.8 | **0.019** |
| Angioedema | 16 | 6.9 | 12 | 9.3 | 0.420 | 15 | 8.8 | 13 | 6.8 | 0.483 | 14 | 7.0 | 14 | 8.7 | 0.559 |
| Pain/swelling in the salivary gland | 13 | 5.6 | 14 | 10.9 | 0.071 | 14 | 8.2 | 13 | 6.8 | 0.616 | 14 | 7.0 | 13 | 8.1 | 0.710 |
| Lupus like reactions | 16 | 6.9 | 10 | 7.8 | 0.772 | 11 | 6.5 | 15 | 7.9 | 0.602 | 11 | 5.5 | 15 | 9.3 | 0.167 |
| Erythema multiforme | 9 | 3.9 | 14 | 10.9 | **0.010** | 5 | 2.9 | 18 | 9.5 | **0.011** | 7 | 3.5 | 16 | 9.9 | **0.013** |
| Pemfigoid-like reactions | 6 | 2.6 | 10 | 7.8 | **0.023** | 6 | 3.5 | 10 | 5.3 | 0.426 | 8 | 4.0 | 8 | 5.0 | 0.664 |
| Do not know | 23 | 10.0 | 22 | 17.1 | 0.051 | 29 | 17.1 | 16 | 8.4 | **0.013** | 25 | 12.6 | 20 | 12.4 | 0.968 |

*More than one option could be selected.
*ADR*, Adverse drug reaction; *GD,* General dentist; *SD,* Specialist dentist.

Dentists may be the first to observe an ADR to a drug prescribed elsewhere, although ADRs in dental practice are less frequently observed than in medical practice.[26] Therefore, dentists should be familiar with the drugs that cause oral mucosal ADRs. Unfortunately, poor knowledge about these drugs was significantly higher in the group of GDs and participants with >12 years of experience in this study. Furthermore, SDs and participants with ≤12 years of experience were more aware of ADRs due to antifungals, anti-inflammatory mouthwashes and sedatives/general anesthetics. These findings could be explained by the fact that SDs prescribe a wide spectrum of drugs and manage the treatment of medically compromised patients more frequently, in addition to having more advanced educational levels and being more eager to update their knowledge about drugs compared to GDs. Moreover, the greater knowledge of dentists with ≤12 years of experience may be an outcome of the improvements in PV activities in Turkey with the publication of subsequent regulations in 2014 after the establishment of ADR reporting system in 2005.[9]

In the suspicion of an oral mucosal ADR, the primary attitudes of participants were to consult with a physician and to discontinue the suspected drug. Regarding all the selected options, the findings of this study suggest that most dentists lack the experience to manage oral mucosal ADRs properly. Dentists should manage minor suspected ADRs. However, if a serious/severe ADR occurs, the patient should be immediately referred to the hospital. GDs seemed to have a greater tendency to hospitalize patients.[27] Additionally, the willingness of dentists to inform authorities was also found to be quite low (24.4%) in this study.

Since 2013, the Higher Education Council has included PV training in the curricula of HP schools.[7] This may explain the higher rate of participants with ≤12 years of experience who received training about ADRs during their undergraduate education.

Educational interventions and other activities to promote ADR reporting have been shown to increase awareness of ADRs, thus increase the ADR reporting rates.[28,29] Unfortunately, the low ADR reporting rate among dentists (2.8%) was not compatible with receiving training about ADRs (50.3%) in this study. This finding indicates that the inclusion of PV and ADR reporting trainings in conferences/continuing education course programs in addition to education curricula is highly needed for dentists.

We believe that the findings of this study will help to guide authorities in defining the training needs and practice points of dentists regarding PV and ADR reporting. The practice points must include the diagnosis and treatment steps of ADRs and ADR reporting as well as rational drug use and accurate prescribing activities. Implementation of these training programs at both the undergraduate and postgraduate levels of dentistry would help to improve the dentists' skills in diagnosing and managing ADRs. Additionally, these activities should be mandatory for all dentists in Turkey. Furthermore, integrating the ADR reporting system into the electronic prescribing system or developing a mobile application for ADR reporting to facilitate the reporting process, providing feedback by the TUFAM to ADR reporters will help to improve reporting rates.[30]

The most important limitation of this study was its sample size. Future studies with a greater number of participants, including both GDs and SDs, can represent the exact KAP of dentists in Turkey. However, this was a multicentric study among dentists working in different institutions, and Istanbul is the largest metropolis in Turkey. Therefore, our study population represented a small sample of Turkey. Another limitation was the electronic distribution of the questionnaire, which may have caused selection bias. Additionally, some of the dentists might have been discouraged from participating because of the length of the questionnaire.

## Conclusions

The role of dentists in the diagnosis and reporting of ADRs should not be underestimated since they are an integral part of the health care system. The contribution of both GDs and SDs to the ADR reporting system needs to be improved in Turkey and worldwide. Future attempts should be made to increase awareness about PV and ADRs among dentists and to improve the skills of dentists in the diagnosis and reporting of ADRs. Additionally, ADR reporting should be integrated into the daily practice of dentists.

## Acknowledgments

The authors thank all the dentists who participated in the present study by filling out the questionnaire.

## Conflict of Interest

Authors declare no conflict of interest.

## References

1. de Ameida PDV, Johann ACBR, de Azevedo Alanis LR, de Lima AAS, Grégio AMT. Antidepressants: Side Effects in the Mouth. In: Mandeep Virdi (Editor). Oral Health Care-Pediatric, Research, Epidemiology and Clinical Practices. INTECH Open Access Publisher 2012:113-128.
2. Ikeda K. Drug-Induced Oral Complications. Atlas Oral Maxillofac Surg Clin North Am 2017;25:127-132.
3. Ouanounou A, Ng K, Chaban P. Adverse drug reactions in dentistry. Int Dent J 2020;70:79-84.
4. Femiano F, Lanza A, Buonaiuto C, Gombos F, Rullo R *et al.* Oral manifestations of adverse drug reactions: guidelines. J Eur Acad Dermatol Venereol 2008;22:681-691.
5. Shehab N, Patel PR, Srinivasan A, Budnitz DS. Emergency department visits for antibiotic-associated adverse events. Clin Infect Dis 2008;47:735-343.
6. Yip J, Radford DR, Brown D. How do UK dentists deal with adverse drug reaction reporting?. Br Dent J 2013;214:E22.
7. Güner MD, Ekmekci PE. Healthcare professionals' pharmacovigilance knowledge and adverse drug reaction reporting behavior and factors determining the reporting rates. J Drug Assess 2019;8:13-20.
8. Karataş Y, Khan Z, Gören Özagil ES, Abussuutoğlu AB, Pelit A *et al.* Knowledge, attitude and practices about pharmacovigilance and adverse drug reactions among dental research assistants in a Turkish hospital: a cross-sectional study. J Health Sci Med 2020;3:367-371.
9. Ozcan G, Aykac E, Kasap Y, Nemutlu NT, Sen E *et al.* Adverse Drug Reaction Reporting Pattern in Turkey: Analysis of the National Database in the Context of the First Pharmacovigilance Legislation. Drugs Real World Outcomes 2016;3:33-43.
10. Toklu HZ, Uysal MK. The knowledge and attitude of the Turkish community pharmacists toward pharmacovigilance in the Kadikoy district of Istanbul. Pharm World Sci 2008;30:556-562.
11. Oguz E, Alasehirli B, Demiryurek AT. Evaluation of the attitudes of the nurses related to rational drug use in Gaziantep University Sahinbey Research and Practice Hospital in Turkey. Nurse Educ Today 2015;35:395-401.
12. Vural F, Ciftci S, Vural B. The knowledge, attitude and behaviours of nurses about pharmacovigilance, adverse drug reaction and adverse event reporting in a state hospital. North Clin Istanb 2015;1:147-152.
13. Shroukh WA, Shakhatreh FM, Yasein NA, Sharkas GF. A survey on the knowledge, attitudes and practices of physicians

towards pharmacovigilance in Jordanian health centres. Int Health 2018;10:363-370.

**14.** Hussain SA, Abbas AN, Habeeb SA, Abd-Ali AK, ZS Abdulrahman. Healthcare personnel's experience of reporting adverse drug reactions in Baghdad city: cross-sectional study. Int J Clin Pharm 2019;41:1307-1313.

**15.** Hallit S, Hajj A, Shuhaiber P, Iskandar K, Ramia E *et al.* Medication safety knowledge, attitude, and practice among hospital pharmacists in Lebanon. J Eval Clin Pract 2019;25:323-339.

**16.** Ergün Y, Ergün TB, Toker E, Ünal E, Akben M. Knowledge attitude and practice of Turkish health professionals towards pharmacovigilance in a university hospital. Int Health 2019;11:177-184.

**17.** Khan SA, Goyal C, Tonpay SD. A study of knowledge, attitudes, and practice of dental doctors about adverse drug reaction reporting in a teaching hospital in India. Perspect Clin Res 2015;6:144-149.

**18.** Torwane NA, Hongal S, Gouraha A, Saxena E, Chavan K. Awareness related to reporting of adverse drug reactions among health caregivers: A cross-sectional questionnaire survey. J Nat Accred Board Hosp Healthcare Providers 2015;2:23-29.

**19.** Sudhakar S, Madhavan A, Balasubramani S. Attitude of dentists toward pharmacovigilance and reporting adverse drug reactions: A cross-sectional study. J Adv Clin Res Insights 2015;2:242-247.

**20.** Ozgen ZE, Erdogmus Z. Investigation of Dentists' Opinions on Pharmacovigilance and Reporting of Adverse Effects. Dicle Med J 2021;48:696-702.

**21.** Şencan MN, Özyazıcı T. Dentists' Knowledge On Pharmacovigilance: A Preliminary Study in Istanbul. Hacettepe University Journal of the Faculty of Pharmacy 2021;41:1-8.

**22.** Jadhav A, Chandrikapure A, Tarte P. Pharmacovigilance in dental practice: A study to evaluate knowledge, attitude and practices (KAP) of reporting of adverse drug reactions (ADR) among dental practitioner in a city of central region of Maharashtra, India. MedPulse-International Journal of Dentistry 2017;2:14-18.

**23.** Bishen KA, Anil B, Madhusudan A. A study on knowledge, attitude and practices of private dental practioners regarding pharmacovigilance and adverse drug reaction reporting in Jodhpur City, India. European Journal of Biomedical 2018;5:652-657.

**24.** Herdeiro MT, Figueiras A, Polo´nia J, Gestal-Otero JJ. Influence of pharmacists' attitudes on adverse drug reaction reporting: a case–control study in Portugal. Drug Saf 2006;29:331-340.

**25.** Teoh L, Moses G, McCullough MJ. A review and guide to drug-associated oral adverse effects-Dental, salivary and neurosensory reactions. Part 1. J Oral Pathol Med 2019;48:626-636.

**26.** Seymour RA, Meechan JG, Yates M. Pharmacology and dental therapeutics. 3rd ed. Oxford: Oxford University Press 1999.

**27.** World Health Organization. Safety of medicines: a guide to detecting and reporting adverse drug reactions: why health professionals need to take action. Geneva: World Health Organization 2002.

**28.** Ribeiro-Vaz I, Santos CC, Cruz-Correia R. Promoting adverse drug reaction reporting: comparison of different approaches. Rev Saude Publica 2016;50:14.

**29.** Ganesan S, Sandhiya S, Reddy KC, Subrahmanyam DK, Adithan C. The Impact of the Educational Intervention on Knowledge, Attitude, and Practice of Pharmacovigilance toward Adverse Drug Reactions Reporting among Health-care Professionals in a Tertiary Care Hospital in South India. J Nat Sci Biol Med 2017;8:203-209.

**30.** Khan Z, Karataş Y, Rahman H. Adverse drug reactions reporting in Turkey and barriers: an urgent need for pharmacovigilance education. Ther Adv Drug Saf 2020;11:1-3.

Cumhuriyet Dental Journal, 26(1): 77-86, 2023
DOI: https://doi.org/10.7126/cumudj. 1241456

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 | Available online, ISSN: 1302-5805 e-ISSN: 2146-2852 | Publisher: Sivas Cumhuriyet Üniversitesi

# *Use of Micro Computed Tomography in Prosthetic Dentistry*

***Kübra Tokay Kızılırmak[1-a*], Evşen Tamam[1-b]***

*[1] Department of Prosthetic Dentistry, Gazi University Faculty of Dentistry, Ankara, Türkiye.*
**Corresponding author*

**Review**

*History*

*Received: 01/12/2022*
*Accepted: 28/01/2023*



**ABSTRACT**

Today, the use of micro-computed tomography is becoming widespread in almost every field of dental research. When the national review articles on micro-computed tomography are examined, it is seen that the focus is on endodontic and surgical dental applications. As prosthodontists, our article, which was compiled in order to deepen the specific usage areas of micro-computed tomography applications and to review the studies done in this area, provides information about the use of micro-computed tomography method in prosthetic dentistry. Micro-computed tomography is a powerful *in vitro* research method. Micro-computed tomography was used; marginal and internal compatibility of restorations, cement spacing of restorations, adaptation of denture bases, accuracy of prosthetic measurements, effects of occlusal irregularities, volumetric changes in teeth due to dental post application, biomechanical evaluation of implant-abutment connection, and compatibility of maxillofacial prostheses.

***Keywords:*** Computed Tomography, Dental Implant, Marginal and Internal Fit, Maxillofacial Prostheses.

a *kubratokay@yahoo.com* *https://orcid.org/0000-0002-4436-0775* b *ewsen@gazi.edu.tr* *https://orcid.org/0000-0002-3696-6734*

*How to Cite:* Tokay Kızılırmak K, Tamam E. (2023) Use of Micro Computed Tomography in Prosthetic Dentistry, Cumhuriyet Dental Journal, 26(1):77-86.

## Introduction

Since the discovery of X-ray by Rontgen in 1895, technology has revolutionized diagnostic medicine, making it feasible to examine the internal structure of the body in a non-invasive way.[1] This method provided a breakthrough in diagnosis and treatment in the field of medicine and pioneered other methods. Computed tomography (CT) is the product of combining X-ray with computer technology. Imaging with CT was first developed in the early 1970s. The microtomography system was first developed by Jim Elliott in 1980, and a small tropical snake was investigated with 50 µm resolution for the first time.[2]

The X-ray passes through the object being examined and the images obtained are two-dimensional (2D). When the object is exposed to x-rays from different angles, images can be converted into three-dimensional (3D) images using computer algorithms. Some frames are reached when the images on CT devices are enlarged. These frames are made up of voxels and pixels, which in turn make up the image. A pixel defines a point in 2D. The voxel, on the other hand, is a unit volume and adds a third dimension to the digital image element, the pixel.[3] The volume elements (voxels) used in clinical CT pictures are typically 1 $mm^3$ in volume, however X-ray micro-CT systems provide far superior spatial resolution and generate voxels that are 1,000,000 times smaller in volume than CT voxels.[4,5] The large number of sections taken from the sample increases the image resolution achieved by obtaining more detailed information from the sample.[2] Micro-CT devices are similar in structure to CT devices. However, there are two main differences between micro-CT devices and CT devices. First, in CTs, the X-ray source and detector rotate around the patient, which causes mechanical vibration. However, in micro-CT, the x-ray source and detector are generally stationary, while the small object is rotated around its axis. Thus, vibration decreases and resolution increases. The second difference is in CTs the X-ray source size is 1 mm but in micro-CT the size is 5-50 µm. The smaller the source increases the projection depth. Images can be evaluated qualitatively and quantitatively.

In many views, images are rebuilt to create 3D spatial distribution maps of attenuated materials or material density within tissues like teeth.[6] By comparison, conventional radiography was restricted to providing 2D images representing the amount of material attenuation along the X-ray track. The process of creating 3D images that show the examined structures in more detail by using various computer programs from microtomographic data is '3D reconstruction', which is expressed as reconstruction. High-resolution detectors and a microfocal X-ray source (90–150 kVA) are used in micro-CT systems to recreate the materials' 3D surfaces. Allows rotated projections along multiple viewing directions. The images symbolize spatial

distribution maps of linear attenuation parameter specified by the atomic composition of the sample and the energy of the X-ray source. Since the imaging technique does not devastate the samples, both internal and external features of the same sample can be inspected more than once.

Micro-CT can be used to directly investigate a wide range of samples, including materials like ceramics, polymers, biomaterial infrastructures, and mineralized tissues like teeth and bones. Soft tissues, such as the lungs, that have been infiltrated or perfused with a contrast agent that has a higher density than the surrounding tissues can also be examined using micro-CT imaging. The latest generation of micro-CT systems enables *in vivo* imaging of small live animals.[8,9] The micro-CT device, which also finds use in dentistry, has taken its place in the majority of dental research. This article's goal is to review the use of micro-CT in research on prosthetic dentistry.

## *1. Micro-CT Usage Areas in Prosthetic Dentistry*

### *1.1. Evaluation of marginal and internal fit of restorations*

The long-term clinical success of fixed partial dentures is also evaluated by the compatibility of the restoration with the supporting structures. Marginal discrepancy lead to microorganism accumulation and soft tissue proliferation[10]; these cause biological problems (inflammation, etc.). Biological problems are more common than mechanical problems among the reasons for the replacement of prosthetic restorations.[11] Marginal discrepancy lead to plaque accumulation, increasing the risk of caries in the abutment teeth.[12] Deficiencies in the marginal fit of the crown (>120 µm)[13] will result in microleakage and rapid dissolution of the cement. As a result, biological complications such as pulpitis, secondary caries and periodontal problems will occur in the future. Marginal and internal fit is assessed with the following techniques. It is possible to perform examination using the silicone replica technique, clinical examination with the probe, which is a qualitative evaluation, examination with bite-wing x-rays, 2D examination with stereomicroscope and micro-CT. With the micro-CT method, it is possible to make measurements that can be repeated from many points without damaging the restoration, abutment tooth or cast model.[14] There are studies assessing the marginal and internal fit of different production techniques, different step types, different preparation techniques, various prosthetic materials and designs with micro-CT.

In a study in which marginal fit of various In-Ceram alumina ceramic cores produced with four different techniques (Wol-Ceram, Slip cast, Celay) were evaluated, micro-CT was preferred as examination method, marginal space and marginal discrepancy were tested mesiodistally and buccolingually with micro scale.[15] Unlike production techniques influenced the marginal fit of full-ceramic restorations. The slip-cast method and the Wol-Ceram system showed the greatest marginal fit, pursued by the Cerec inLab with clinically satisfactory results.

Borba *et al.* [16] used a novel approach based on micro-CT technology to assess the marginal and internal fit of zirconia-based all-ceramic three-unit fixed partial dentures (Y-TZP - LAVA). Five measurement points were selected for micro-CT scans: marginal gap; chamfer step area; axial wall; axio-occlusal transition area; occlusal area. Significant differences in gap width were observed between the evaluated measurement points. The marginal gap exhibited the smallest gap size. The occlusal area had the largest gap size, pursued by the axio-occlusal transition area point. Chamfer step area and axial wall gap size values were found to be statistically comparable. It was therefore able to draw the conclusion that varying degrees of adaptation were seen in fixed partial dentures at various measurement points.

Demir *et al*.[17] preferred micro-CT as the examination method before and after cementation in a study where they evaluated the marginal gap and marginal mismatch of all-ceramic crowns with chamfer and shoulder finish line styles. Samples are sectioned into two groups according to the finish line design: shoulder and chamfer. All-ceramic crowns are further grouped by type: Feldspathic, aluminum oxide ceramic system and Lithium disilicate press ceramic system. Prior to cementation, five crowns from each group were examined with micro-CT in sagittal and coronal section to detect marginal gap and marginal discrepancy values for four different areas of the crown. Scanning was repeated after cementation and thermal cycling. As a result of the study, all-ceramic systems revealed clinically admissible marginal adaptation rates. The Feldspathic ceramic system revealed minimum overall change, exception for the marginal gap rates of the coronal mesial area.

In the study evaluating the marginal and internal adaptation of crown copings produced from three various materials, nickel-chromium alloy, zirconia and lithium disilicate, micro-CT was preferred to acquire volumetric reconstructions from every sample.[14] It was determined that the casting metal alloy showed the greatest overall marginal fit and lithium disilicate the best general internal fit. General evaluation of the results revealed that all materials tested were within the clinically accepted level despite significant differences in compliance.

Kim *et al*.[18] aimed to measure the marginal and internal fit of lithium disilicate crowns produced from digital and traditional impressions with micro-CT. The CS3500 intraoral digital impression system, Trios intraoral digital impression system, Ceramill Map400 extraoral digital impression system, and heat-press process were used to create lithium disilicate crowns. Within limitations of this investigation, the results show that the fit of lithium disilicate crowns made using digital techniques is equivalent to the traditional heat-press technique for clinical usage. IPS e.max CAD crowns fabricated using the CS3500 intraoral scanner revealed considerably better marginal fit than those of the other 3 groups and there was only a small internal mismatch relative to the Trios scanner. Between IPS e.max Press crowns produced with the heat-press method and IPS e.max CAD crowns produced utilizing the extraoral scanner and Trios intraoral scanner, no difference in marginal or internal fit were found.

Micro-CT was preferred as the examination method in the study in which the marginal fit of Co-Cr alloy copings manufactured with traditional casting and 3 different CAD/CAM were evaluated.[19] Two different commercial alloy systems were used for each production technique. The milling and selective laser melting groups displayed considerably higher marginal discrepancy than the comparison groups, while the milling/sintering groups displayed significantly lower rates than the control group. Milling groups showed considerably higher marginal discrepancy than comparison groups. In selective laser melting and milling/sintering groups, marginal mismatch rates are material typical. However, the milling/sintering groups showed approximately equivalent or less marginal discrepancy with the comparison groups. According to the results of this *in vitro* micro-CT revealed that the marginal adaptation rates of the Co-Cr largely depend on the production processes and sometimes the alloy types.

In a study evaluating marginal and internal fit of lithium disilicate inlays fabricated with two different axial milling systems and conventional method probable gaps in different areas were analysed.[20] As a result, different manufacturing methods had an impact on the internal and marginal fit of inlays. The conventional group demonstrated the greatest marginal and internal fit outcomes; even so, all samples in each group were within the clinically reasonable marginal range limit. Among the CAD/CAM groups, the five-axis system showed preferable axial-internal fit and occlusal-marginal fit rates than the three-axis system.

Micro-CT was preferred as the examination method in the study, which evaluated the external (vertical and horizontal) and internal adaptation of implant crowns produced with four different production techniques and reported that the best results belong to the CAD/CAM production technique.[21] In the statistical analysis, it was seen that there was no important difference among the groups for vertical discrepancy. While there was no important difference for internal and marginal discrepancy in conventional casting groups, it was observed for CAD/CAM milling group.

Duqum *et al*.[22] aimed to investigate the marginal fit of all-ceramic crowns constructed of lithium disilicate and zirconia with micro-CT using two different manufacturing processes of CAD/CAM. Both workflows are legitimate techniques for the producing of monolithic ceramic restorations. Lithium disilicate or zirconia crowns' marginal match was not improved by printed model. Regardless of which workflow was used to achieve the restoration, both materials have clinically acceptable marginal fit.

Micro-CT was preferred as the examination method in the study in which the marginal and internal adaptation of full-ceramic inlays designed using three different CAD systems (CEREC, Dentsply Sirona, York, PA; KaVo, Everest, Germany and Planmeca, Helsinki, Finland) were evaluated.[23] A total of 363 measurements were made, 11 measurements for each sample. In the study, it was found that the software programs of different systems affect the marginal and internal adaptation of inlays.

Ekici *et al*.[24] aimed to evaluate the marginal and internal fit of full-ceramic crowns and inlays manufactured using two intraoral scanners and a model scanner with micro-CT. For local linear measures on full-ceramic crowns, there was often no variation between scanners, although gaps were more noticeable in restorations performed with intraoral scanners for volumetric measurements. But when the inlay repairs were examined, there were noticeable variations amongst the groups. The marginal and internal gap of both crowns and inlays showed average rates that could be considered clinically acceptable.

In a study aimed to evaluate external gap progression in three dimensions after chewing simulation of highly translucent zirconia and zirconia-enhanced lithium silicate with different preparation design applied to endodontically treated teeth. The external gap progression of the adhesive overlay and full crown models prepared on the enamel-cementum border of the molar teeth was evaluated in three dimensions before and after the chewing simulation. The full crown preparation design was found to have a considerably lower gap process regarding the overlay preparation. Zirconia-enhanced lithium silicate exhibited significant inferior gap progression compared to highly translucent zirconia. Preparations restored with zirconia-enhanced lithium silicate appear to perform better in sealing the external margin after cyclic fatigue.[25]

Tamam *et al*.[26] evaluated the fit of CAD-CAM ceramic restorations following different preparation procedures with micro-CT. In the study, monolithic feldspathic ceramic crowns with a total of 28 anatomical contours were produced for 4 tipodont teeth. The preparation groups are as follows: finishing with extra coarse (181 µm) diamond rotary instrument (EC), extra coarse grain diamond rotary instrument followed by fine grain (40 µm) grinding with diamond rotary instrument (F), extra coarse grain and fine grain diamond after finishing with rotary instrument, finishing with extra fine (20 µm) diamond rotary instrument (VF) and polishing with rubber (P) after all process steps have been applied. Micro-CT scanning was preferred to determine the gap among tipodont teeth and crowns. 196 measurements were taken, and reference points including the margin, chamfer, tubercle tips, and central fossa were identified. In all areas, the extremely coarse grained diamond rotary instrument group resulted in the largest gap values. The lowest interval value at the marginal area was seen in the P group. As a result of the study, it was seen that for monolithic feldspathic CAD-CAM restorations, the surface finishing technique with fine grained rotary instruments provided greater marginal fit.

### *1.2. Evaluation of cement space of restorations*

The grade of the marginal fit and the thickness of the bonding material are among the factors affecting the durability of ceramic restorative materials.[27] Another factor in the endurance of restorative material is the gap filled with cement in the 3D plane between the restoration and the tooth surface. In general, 3D adaptation is direct impacted by the thickness of the cement layer. A restoration's internal and marginal cement thickness can be

measured using techniques like sectioning, silicon replica, or micro-CT. Among the various techniques used to evaluate the cement thickness of dental restorative materials, micro-CT is more widely used due to its ability to perform quantitative analysis, repeatability at different time intervals without damaging the samples.[14,28]

Micro-CT technique was used in the study to evaluate the marginal and internal cement thicknesses of inlay restorations produced of different CAD/CAM materials, and the restorations were found to have clinically acceptable cement thickness.[29]

In the study investigating the effects of two different cement (Panavia, Variolink II) systems with different cement thicknesses on full-ceramic crowns on the stress distribution between the crown and the core, micro-CT was preferred as the examination method.[30] Cement with a greater elastic modulus resulted in reduced tensile stress in the crown and core layers, and the shear strength of the cement was found to be critical to the strength of the full-ceramic crown. Evaluation of different cement space has shown that there is an ideal thickness that can minimize the stress level in full-ceramic crowns; however, it has been stated that the cement thickness is of minor effect on the stresses in the core or crowns.

Al-Saleh *et al*. evaluated the microleakage and fracture stresses of full-ceramic veneers bonded with traditional polymeric resin (Multilink N) and two different polymeric bioactive cements (ACTIVA, Ceramir) in order to assess their color stability.[31] According to the type of cement used, all produced samples were randomly separated into three groups. All samples were aged for 30,000 cycles. This samples were used to check with a micro-CT for microleakage. Relative to Multilink N and ACTIVA, Ceramir exhibited the most microleakage.

### *1.3. Evaluation of adaptation of denture bases*

Full dentures and removable partial dentures continue to be a frequently applied treatment option for partially or totally edentulous patients. One of the most significant factors determining the performance of these prostheses is the fit of the base of the prosthesis to the mucosa and the retention provided when the gap between the base and the tissues is as small as possible.[32] The fit of the denture base may vary according to different production techniques or the applied arch. Denture base fit has been frequently examined using various methods such as stereomicroscopic space quantification of denture bases by taking sections on the plaster model, measurement of the physical mass or thickness of the elastomeric impression material positioned between the denture base and the plaster model, and digital superimposition analysis.[33-35] All these procedures assessed fit by examining the space between the denture base and the plaster model representing the underlying mucosa. Micro-CT, a technique often employed in dental research, can visualize internal structures without damaging the structures with 3D imaging and can not only take linear and yet also volumetric assessments of space among or within materials.[36] This modern method can be a useful tool for evaluating denture base adaptation.

Micro-CT method was used in the study in which the fit of denture bases produced with four different production methods (conventional pressure, conventional injection, PMMA milling method and 3D printing method) was evaluated.[37] In this study, 3 areas in the mandible and 6 areas in the maxilla were measured to assess the denture base adaptability. It has been found that denture bases milling from PMMA show greater adaptability for both maxillary and mandibular jaws than 3D printing or conventionally fabricated denture bases.

### *1.4. Evaluation of the accuracy of prosthetic impression*

The correct and clear impression of the tooth prepared to be restored should be taken. Conventional and digital methods are used in the impression process. The conventional impression is to obtain the negative with various impression materials to replicate the surface contour of the prepared tooth, its connection with adjacent teeth and soft tissue. Although this technique is considered the gold standard for providing precise and reliable details concerning patients' intraoral conditions[38], it has many disadvantages such as cumbersome procedures, dependence on the skill and experience of the clinician, and storage problems. The digital impression is produced indirectly by scanning the traditional impression, the plaster model produced from the conventional impression, or by direct scanning of the prepared tooth with an intraoral scanner. Compared to traditional systems, digital impression systems have advantages such as increased patient satisfaction, decreased time and expense performance, reduction of errors due to volume changes and user-related mistakes, material savings and a cleaner environment.[39] It has also been reported that digital impression accuracy is similar to conventional impression.[40] Restorations can be produced directly via CAD/CAM systems using digital impressions, and the restoration is often completed in a single appointment. In another workflow, the model obtained indirectly from a conventional impression or impression is scanned and its data is transferred to electronic media and restorations are produced in the laboratory.

Li *et al*.[41] obtained a three-dimensional digital dental model with a 90 µm scanning layer by using micro-CT from the dental impression and presented micro-CT as an alternative for creating a dental model.

Kim *et al*.[42] compared the impression phase of crown and inlay restoration fabrication with the extraoral optical method (laboratory scanner), the intraoral optical method (intraoral scanner), and their own method (scanning the impression with micro-CT). Although different methods were used in terms of functioning, no significant difference was found between them. The proposed method has been shown to be comparable to extraoral optics and intraoral optics in conditions of dimensional accuracy. According to the outcomes of the variation map analysis, it has been shown that the recommended method has considerably less deviations not only on the tooth surface but also in the gingival tissues with respect to the intraoral optical method. They also evaluated the restorations obtained from all

three methods and showed that the proposed method was comparable to existing methods in conditions of appearance and marginal fit.

In a research conducted by Hamm *et al*.,[43] the models produced from six different materials (Type IV hard plaster, cobalt-chromium-molybden, epoxy resin, polyurethane, titanium, zirconia) were evaluated. Over the course of six weeks, 3D data sets of models were produced using Micro-CT at various intervals. Cobalt-Chromium-Molybden and zirconia scans have shown the best sensitivity. While the polyurethane model does not satisfy the requirement of dimensional stability, the epoxy and type IV Hard plaster remained stable for only 10 days.

### *1.5. Evaluating the Effects of Occlusal Interference*

Due to the early contact or lateral loads, excessive force is transferred to the teeth from prostheses and this mechanical stress may affect periodontal tissues. Excessive mechanical stress and hyperocclusion are called occlusal trauma, a type of periodontitis. Radiographic evidences in individuals with occlusal trauma, the destruction of the alveolar crest in early stages and the expansion of the interval of the periodontal ligament, then the demineralization of the alveolar bone and the loss of tooth in the following stages.[44] Recent research, has attempted to investigate alveolar bone alterations using micro-CT.[45] It was also used to evaluate the destruction of the orthodontic tooth mobility and periodontitis-related periodontal tissue damage. Micro-CT was also employed to evaluate bone patterns in segmental osteotomy research.[46]

As a result of the bone being destroyed during hyperocclusion, high mechanical stress can lead to periodontal disease. In response to hyperocclusion in rat, micro-CT was used in the study aimed at analyzing alveolar bone resorption.[47] Under anesthesia, a stainless steel wire is connected to the teeth of the rat to induce extra occlusal force loading. On the days of 0 and 7, hard tissue samples were examined with micro-CT. As a result of the research, significant bone resorption was observed on the 7th day compared to initial. This study has provided the possibility of effective examination from a prosthetic perspective of alveolar bone resorption, and the topographic images obtained have enabled hard tissue changes that cannot be detected by immunohistochemical alone.

There is a biomechanical relationship between temporomandibular joint (TMJ) and occlusion. Incorrectly created occlusion initiates degenerative responses in TMJ condyles. Aging is a factor that promotes the development of osteoarthritis. Zhang *et al* .[48] aimed to evaluate the effect of aging on degenerative remodes in TMJ condyles in response to occlusal biomechanical stimuli caused by the prosthesis used without compliance with the rules and to observe rehabilitation after prostheses were removed. In this study, the bilateral anterior cross bite model was developed to 84 female rat groups and TME 3, 7 and 11 was examined in weeks. Prostheses made with bilateral anterior cross bite model were made for 7 weeks and evaluations were made 4 weeks after the prosthesis were removed. TMJ changes were examined by micro-CT, histomorphology, immunohistochemistry and immunofluorescent painting experiments. The results have shown that bilateral anterior cross bite model causes more severe osteoarthritis-like TMJ lesions in older groups. The elimination of the bilateral anterior cross bite model has reduced the degenerative changes in the condylar cartilage and subcondral bone. The effect of healing has been found to be more pronounced especially in young animals.

### *1.6. Evaluation of the volumetric change in teeth due to dental post application*

It is very difficult to decide on the treatment when post application is required. The posts are used to protect the remaining tissues when a large part of the tooth is lost. Access cavity and post socket preparation are processes that cause great loss of the hard tissue structure during root canal treatment. It is crucial to quantify the quantity of dentin eroded at each step of the root canal process and after the restoration to determine how the destruction of dental tissue brought on by restorative processes and root canal treatment might damage the tooth. During root channel instrumentation, high-resolution micro-CT is frequently utilized to assess the 3D volumes and geometries of canals.[49] In a study, in which the micro-CT method was preferred to examine the volume changes occurring in the dental hard tissue after endodontic procedures and it was found that the preparation of the post slot for casting post causes more dental tissue loss than fiber post socket preparation, it was founded the post socket preparation for the cast post caused a greater loss of dental tissue than the fiber post socket preparation.[50]

Micro-CT was preferred as the examination method in the study, which planned to impartially compute the volumetrical alteration of endodontically treated and post-applied teeth before and after removing the prefabricated post, and to compare the dentin volume between the samples by evaluating the alteration in tooth volume.[51] Stainless steel Parapost and glass fiber reinforced composite post samples are classified into two groups based on the post system being utilized. Half of the posts for each group were cemented with glass ionomer cement and the other half are Dual-Cure resin cement. Compared to other posts and cement combinations, the climped parallel-edged stainless steel posts with glass ionomer cement were extracted by using ultrasonic vibration method and caused the maximum loss of tooth root structure.

Chang *et al*.[52] used micro-CT, finite element analysis (FEA) and *in vitro* fatigue analysis in their study to understand the mechanism of the early dissolution of the luting cement layer occurring in the apical and peri-apical regions of fiber posts in an endodontically treated premolar tooth. The six mandibular premolars with canal treatment were examined with micro-CT prior to and during the fatigue test and various materials (dentin, bonding cement and gap) were defined to assess the volume/position of the gap. Oblique loads were applied to assess the mechanical behavior of the cement layer and fatigue tests were performed that simulate one-year chewing to compare it

with the results of FEA. Most of the gaps occurred in the apical one-third of the fiber post, these gaps caused the fiber post to be released and created a stress concentration on the gap limit. In the FEA, it was found that fatigue life has decreased in experimental tests with increasing stress value/micro motion.

In the study of Soares *et al*. [53], which aimed to evaluate the size of the spaces among root dentin and titanium or glass fiber post after cementation with self-adhesive resin cement, the canal, cement and post parameters and surface spaces were measured along the cervical region of the tooth. In self-adhesive cements, the presence of interfacial gaps along the root canal was observed, which was not related to the amount of cement in the canal. There is no important difference among samples containing glass fiber or titanium, and both post kinds have a faultless interface with decimals. They reported that micro-CT is an excellent procedure to examine root canal restorations of hydrated specimens in 3D.

### *1.7. Evaluation of changes in the implant-abutment connection*

Nowadays, dental implants are preferred because they reclaim the function and aesthetics of failure teeth and improve the quality. Two-piece titanium dental implants have been effectively employed in dental professionals for many years.[54] They need to resist the dynamic forces in the oral cavity[55] and the mors-angle (tapered) implant-abutment connections have been shown to be more durable to fatigue against mechanic forces.[56] In addition to technical failures such as chipping or fracture, screw or abutment loosening in implant restorations, implant fractures have been documented in up to 30-41% in 5 years.[57] In addition to technical complications, the prevalence of periimplant mucositis and periimplantitis (43% and 22% respectively) emerges from various biological complications.[58] Although the etiopathogenesis of periimplant diseases has not yet been entirely known, the presence of titanium ions and nanoparticles in the mucosa of periimplantitis have been shown.[59] The micro movement during the loading was defined, but the results were rarely investigated in zirconia abutments.[60] It has been proven that the cyclical loading of zirconia abutments in titanium implants caused the abrasion of titanium implant in butt-joint and conical implant-abutment interfaces.[61]

Blum *et al*.[62] aimed to evaluate the micro gap formation and corrosion pattern during cyclic loading of two-piece dental implants belonging to different systems. Several dental implant systems with various conical implant-abutment interfaces were examined utilizing first synchrotron X-ray high-resolution radiography (SRX micro-CT) and scanning electron microscopy (SEM). The implant-abutment mechanisms were then exposed to cyclic force. Microspaces were assessed after several cycles with SRX micro-CT. The corrosion mechanisms of the implant-abutment connection also characterized by using SEM after specific cycles. As a result of the study, all implants showed a micro gap among the implant and abutment before loading, and this range increased following loading. Regardless of the interface design, corrosion have been observed for all implants tested. The wear pattern is mostly in the form of adhesive corrosion and friction.

Rezende *et al*.[63] purposed to evaluate early loading in various implant platform geometries (external hexagon and morse tapered implant) using micro-CT. Abutment screws were scanned with micro-CT to create digital models. The abutments were torqued to 20 Ncm on the implant and the combination consisting of implant, abutment screw and abutment was transported to the micro-CT scanner and digital sections were obtained from the samples. These cross-sections allowed measurements of screw lengths after torque usage and based on screw elongation. Early loading levels were computed using the Hooke's Law. The extraction torques each sample was saved. To assess the accuracy of the micro-CT method, three rods of known lengths were scanned, and the length of their digital model was assessed and compared to the actual lengths. There was no difference among the groups in terms of early loading values, but the external hexagon group showed higher extraction torque values. The micro-CT method indicated a variation of 0.053% and repeatability deviated from 0.23% to 0.28%. It has been stated that the micro-CT method can be used for early loading calculations.

In a study evaluating micro gap in the screw pitch connection of a two-piece dental implant,[64] the implants were combined with 25 degrees angled abutments and micro-CT was utilized to evaluate the screw pitch engagement intervals under various mechanical conditions. The average range in the unloaded sample, is 2.9 ± 0.9 µm. the average space difference during the cyclic compressive loading was showed insignificant impact for cyclic loading. At 200 N, the micro gap size did not increase under the static compression load, but at 400 N, a considerable increase was observed. The mean micro gap significantly increased in the direction of the force application while significantly decreasing on the opposite side.

Bagegni *et al*.[65] evaluated the impact of dynamic loading on the micro gap of the implant-abutment connection when various superstructure heights are selected. 48 dental implants divided two groups (butt-joint and internal-chronic connection) each containing 24 implants, and also according to the height of the superstructure they were further divided into the subgroup. All samples were exposed to a cyclic load on a chewing simulator with a 98 N force for the $5 \times 10^6$ chewing cycle. The micro gap in the implant-abutment connection was examined before and after loading utilizing micro-CT and light microscope. Regardless of the height of crowns, the micro gap between abutment and implant has significantly decreased following loading in both butt-joint and internal-chronic connections.

Bergamo *et al*.[66] evaluated the effect of aging on the adaptation of zirconia abutments in the implant-abutment connection using two different methods on the and aimed to predict the survival possibility of anterior crowns supported by straight and angled abutments. Abutments were randomly divided into three experimental groups according to their laboratory aging state control, autoclave

aging and hydrothermal reactor aging. Implant-abutment mismatch was identified in straight abutments with micro-CT employing the silicone replica method. For fatigue testing, the abutments were torqued to the implants and attached to standard zirconia crowns. As a result, hydrothermal aging significantly affected mismatch in addition to the possibility of surviving of zirconia abutments at greater loadings.

### *1.8. Biomechanical evaluation using finite element analysis*

Recently, FEA is a common technique used to analyze physical events in the field of engineering and biomechanical. The use in dental research is also popular. Micro-CT scanner can be used to create a more accurate and very sensitive finite element model of smaller components such as teeth, dental implants, and dental restorations. After the micro-CT scan of a tooth, it is feasible to divide enamel, dentin and pulp into different area according to the pixel level rates or mineral volume. Following the preparation and restoration of cavity, various material characteristics are given together with the required limit conditions to mimic stress and strain variation. In a study in which a 3D finite element model of the premolar tooth was created using micro-CT and the restoration of tubercles with composite resin was simulated; it was shown that the stress models were 3D and the stress concentration levels were observed on the surface where the load was placed and near the dentin-composite bond formation.[67] In another study using micro-CT, 3D FEA was formed for dental restorative procedures and simulated various cavity designs (MO/MOD and endocrown preparation) and different restorations (feldspathic porcelain and composite resin). The findings demonstrated that the micro-CT method can produce the elaborated 3D finite element model of the teeth and simulate the effect of various treatments on the distribution of stress.[68]

In a study carried out to make FEA from 3D images obtained from micro-CT scanner and two model dental crowns and three-unit fixed partial prosthesis, tensile stresses in crowns are concentrated on the inner surface of the core, close to the implemented load.[69] For the 3-unit partial prosthesis model, the maximum tensile stresses were located in the substructure, in the cervical region of the connectors and pontics. In this study, micro-CT imaging and Mimics software were combined, emphasizing the importance of 3D models of dental crowns and 3-unit fixed partial prosthesis a design instrument in dental research. It has been stated that the 3D FEA method is an significant instrumenting estimating the stress concentration by encouraging in the structural design of dental restorations.

Micro-CT data was used in a study[70] aiming to evaluate the micro-strain and dislocation caused by dental implant restorations loaded at various levels of osseointegration utilizing FEA. Three different directions of implant loading and two levels of osseointegration were considered in the stress-strain analysis of the bone-implant combination. Bone segments are based utilizing two methods (mechanostatic strain and yield strain). The findings of this study demonstrated that when there is only partial osseointegration and when the implant is loaded by buccolingual stresses, the bone around dental implants is severely stressed. High stresses are placed on the implants in these circumstances. A significant difference in the displacements of partly and fully osseointegrated implants was discovered. Partial osseointegration has been mentioned as a possible danger for implant survival.

In a study aimed to appraise the effect of three different dental implant collar configurations under combined compressive/shear force utilizing FEA, three different models, 0°, 10° and 20°, were created with different implant collar configurations and the implant collar was at the crest level or 2 mm below positioned in D2 quality bone.[71] The maximum strain levels in both cortical and trabecular tissue at the peri-implant bone interface were isolated and evaluated. As a result of the study, all implant models distributed the load at the bone-implant interface with an identical strain model between the models. In contrast, variations were seen in the cervical region, where models with implant collar shapes of 10° and 20° had lower strain magnitudes than the model with the straight configuration. When implants are inserted at the levels of the crestal bone, these values are much lower. No difference was observed in strain values in the apical area. Implant collar configuration affected the strain distribution and amplitude in cortical bone and cancellous bone tissues. To decrease the strain levels in the bone and enhance the load distribution, it has been suggested to prefer 10° and 20° neck configurations instead of flat implant platforms.

### *1.9. Maxillofacial prosthesis applications*

Tissue engineering is a multidisciplinary science that integrates the principles of biology and engineering, providing a specific treatment by producing bioartificial organs in the laboratory and then transplanting them into humans. Tissue engineering is also related to maxillofacial prosthetic applications. Hard and soft tissue deformities, which are secondary consequences of trauma, congenital malformation, and acquired disorders, are an important medical concern.[72] Designs with the developing technology in tissue engineering; it plays an important part in tissue regeneration by maintaining tissue volume, offering temporary mechanical capabilities and biofactors.[73] Micro-CT has been used in tissue engineering studies in last years, and 3D data from samples provide more accurate data than complementary 2D methods.

The pore numbers of maxillofacial silicone elastomer combined with two distinct methods and its impact on color repeatability and stability following two different aging procedures were investigated in a research was used micro-CT.[74] 64 disc-shaped silicone elastomer samples were prepared with two methods as manual mixing and mechanical mixing under vacuum. The pore numbers, volumes and percentages were measured using micro-CT and then aging processes were applied. Color change was observed at the beginning and finish of conditioning. Mechanical mixing under vacuum decreased the pore

numbers and percentages of the silicone elastomer compared to manual mixing. The pore properties of the silicone elastomer affected the color stability.

Artopoulou *et al*.[75] aimed to investigate the microleakage patterns occurring at the interface of two maxillofacial silicone elastomeric with pure titanium when three different primers were used, and to appraise the porosity of the two tested elastomers. The percent degree of linear leakage across the bonded interface was measured by light microscopy. The percentage of void volume fraction was evaluated by micro-CT scanning. Variations in mechanical characteristics, chemical combination, and adjustments during the use of maxillofacial silicone elastomeric have been shown to alter the linear microleakage and porosity of the silicone elastomeric along the pure titanium-silicone elastomer bonding interface.

## Conclusions

Micro-CT method has been proven to be available in the field of prosthetics as well as in many dental studies. The use of micro-CT is increasing day by day, especially in *in vitro* studies. It has become an important part of many academic and industrial research laboratories. Especially with the developments in digital dentistry, it is considered that micro-CT systems will be used as an important evaluation tool in research in prosthetic dentistry, which includes new materials each passing day, and maybe it can shed light on original studies.

## References


1. Dunn PM. Wilhelm Conrad Röentgen (1845–1923), the discovery ofx rays and perinatal diagnosis. Arch Dis Child Fetal Neonatal Ed. 2001;84(2):F138-139.
2. Elliott JC, Dover S. X-ray microtomography. J Microsc. 1982;126(Pt 2):211-213.
3. Güner O, Altıntaş G, Ergüt A. Mikro-CT Çözünürlüğünün Voksel Tabanlı Model ve Analiz Sonuçları Üzerindeki Etkileri-Effect of Micro-CT Resolutions of Voxel Based Model and Analysis Results. Celal Bayar University Journal of Science.2015;11(2):0-.
4. Feldkamp LA, Goldstein SA, Parfitt MA, Jesion G, Kleerekoper M. The direct examination of three-dimensional bone architecture in vitro by computed tomography. J Bone Miner Res. 1989;4(1):3-11.
5. Kuhn JL, Goldstein SA, Feldkamp LA, Goulet RW, Jesion G. Evaluation of a microcomputed tomography system to study trabecular bone structure. J Orthop Res. 1990;8(6):833-842.
6. Hounsfield GN. Computerized transverse axial scanning (tomography): Part 1. Description of system. Br J Radiol. 1973;46(552):1016-1022.
7. Swain MV, Xue J. State of the art of Micro-CT applications in dental research. Int J Oral Sci. 2009;1(4):177-188.
8. Guldberg RE, Ballock RT, Boyan BD, Duvall CL, Lin AS, Nagaraja S, et al. Analyzing bone, blood vessels, and biomaterials with microcomputed tomography. IEEE Eng Med Biol Mag. 2003;22(5):77-83.
9. Guldberg RE, Lin AS, Coleman R, Robertson G, Duvall C. Microcomputed tomography imaging of skeletal development and growth. Birth Defects Res C Embryo Today. 2004;72(3):250-259.
10. Bauer JRdO, Grande RHM, Rodrigues-Filho LE, Pinto MM, Loguercio AD. Does the casting mode influence microstructure, fracture and properties of different metal ceramic alloys. Braz Oral Res. 2012;26(3):190-196.
11. Layton D. A critical appraisal of the survival and complication rates of tooth-supported all-ceramic and metal-ceramic fixed dental prostheses: the application of evidence-based dentistry. Int J Prosthodont. 2011;24(5):417-427.
12. Felton DA, Kanoy BE, Bayne SC, Wirthman GP. Effect of in vivo crown margin discrepancies on periodontal health. J Prosthet Dent. 1991;65(3):357-364.
13. McLean JW, von Fraunhofer JA. The estimation of cement film thickness by an in vivo technique. Br dent j. 1971;131(3):107-111.
14. Pimenta MA, Frasca LC, Lopes R, Rivaldo E. Evaluation of marginal and internal fit of ceramic and metallic crown copings using x-ray microtomography (micro-CT) technology. The J Prosthet Dent. 2015;114(2):223-238.
15. Pelekanos S, Koumanou M, Koutayas S, Zinelis S, Eliades G. Micro-CT evaluation of the marginal fit of different In-Ceram alumina copings. Eur J Esthet Dent. 2009;4(3):278-292.
16. Borba M, Miranda WG, Cesar PF, Griggs JA, Bona AD. Evaluation of the adaptation of zirconia-based fixed partial dentures using micro-CT technology. Braz Oral Res. 2013;27(5):396-402.
17. Demir N, Ozturk AN, Malkoc MA. Evaluation of the marginal fit of full ceramic crowns by the microcomputed tomography (micro-CT) technique. Eur Journal Dent. 2014;8(04):437-444.
18. Kim J-H, Jeong J-H, Lee J-H, Cho H-W. Fit of lithium disilicate crowns fabricated from conventional and digital impressions assessed with micro-CT. J Prosthet Dent. 2016;116(4):551-557.
19. Kim E-H, Lee D-H, Kwon S-M, Kwon T-Y. A microcomputed tomography evaluation of the marginal fit of cobalt-chromium alloy copings fabricated by new manufacturing techniques and alloy systems. J Prosthet Dent. 2017;117(3):393-399.
20. Alajaji NK, Bardwell D, Finkelman M, Ali A. Micro-CT Evaluation of Ceramic Inlays: Comparison of the Marginal and Internal Fit of Five and Three Axis CAM Systems with a Heat Press Technique. J Esthet Res Dent. 2017;29(1):49-58.
21. Moris ICM, Monteiro SB, Martins R, Ribeiro RF, Gomes EA. Influence of manufacturing methods of implant-supported crowns on external and internal marginal fit: a micro-CT analysis. BioMed Res İnt. 2018;2018:5049605.
22. Duqum IS, Brenes C, Mendonca G, Carneiro TAPN, Cooper LF. Marginal Fit Evaluation of CAD/CAM All Ceramic Crowns Obtained by Two Digital Workflows: An In Vitro Study Using Micro-CT Technology. JvProsthodont. 2019;28(9):1037-1043.
23. Bayrak A, Akat B, Ocak M, Kılıçarslan MA, Özcan M. Micro-Computed Tomography Analysis of Fit of Ceramic Inlays Produced with Different CAD Software Programs. Eur J Prosthodont Restor Dent. 2021;29(3).
24. Ekici Z, Kılıçarslan MA, Bilecenoğlu B, Ocak M. Micro-CT Evaluation of the Marginal and Internal Fit of Crown and Inlay Restorations Fabricated Via Different Digital Scanners belonging to the Same CAD-CAM System. Int J Prosthodont. 2021;34(3):381-399.
25. Baldi A, Comba A, Ferrero G, Italia E, Tempesta RM, Paolone G, et al. External gap progression after cyclic fatigue of adhesive overlays and crowns made with high translucency zirconia or lithium silicate. J Esthet Rest Dent. 2022;34(3):557-64.
26. Tamam E, Güngör MB, Nemli SK, Bilecenoğlu B, Ocak M. Effect of different preparation finishing procedures on the marginal and internal fit of CAD-CAM-produced restorations: A

microcomputed tomography evaluation. J Prosthet Dent. 2021;S0022-3913(21)00631-4.
27. Frankenberger R, Sindel J, Kramer N, Petschelt A. Dentin bond strength and marginal adaptation: direct composite resins vs ceramic inlays. Oper Dent. 1999;24(3):147-155.
28. Alfaro DP, Ruse ND, Carvalho RM, Wyatt CC. Assessment of the internal fit of lithium disilicate crowns using micro-CT. J Prosthodont. 2015;24(5):381-386.
29. Uzgur R, Ercan E, Uzgur Z, Çolak H, Yalçın M, Özcan M. Cement Thickness of Inlay Restorations Made of Lithium Disilicate, Polymer-Infiltrated Ceramic and Nano-Ceramic CAD/CAM Materials Evaluated Using 3D X-Ray Micro-Computed Tomography. J Prosthodont. 2018;27(5):456-460.
30. Liu B, Lu C, Wu Y, Zhang X, Arola D, Zhang D. The Effects of Adhesive Type and Thickness on Stress Distribution in Molars Restored with All-Ceramic Crowns. J Prosthodont. 2011;20(1):35-44.
31. Al-Saleh S, Aboghosh TW, Hazazi MS, Binsaeed KA, Almuhaisen AM, Tulbah HI, et al. Polymer-Based Bioactive Luting Agents for Cementation of All-Ceramic Crowns: An SEM, EDX, Microleakage, Fracture Strength, and Color Stability Study. Polymers(Basel). 2021;13(23):4227.
32. Darvell BW, Clark RK. The physical mechanisms of complete denture retention. Br Dent J. 2000;189(5):248-52.
33. Lee C-J, Bok S-B, Bae J-Y, Lee H-H. Comparative adaptation accuracy of acrylic denture bases evaluated by two different methods. Dent Mater J. 2010;29(4):411-417.
34. Hwang H-J, Lee SJ, Park E-J, Yoon H-I. Assessment of the trueness and tissue surface adaptation of CAD-CAM maxillary denture bases manufactured using digital light processing. J Prosthet Dent. 2019;121(1):110-117.
35. Yoon H-I, Hwang H-J, Ohkubo C, Han J-S, Park E-J. Evaluation of the trueness and tissue surface adaptation of CAD-CAM mandibular denture bases manufactured using digital light processing. J Prosthet Dent. 2018;120(6):919-926.
36. Tayman MA, Kamburoğlu K, Küçük Ö, Ateş FS, Günhan M. Comparison of linear and volumetric measurements obtained from periodontal defects by using cone beam-CT and micro-CT: an in vitro study. Clin Oral İnvestig. 2019;23(5):2235-2244.
37. Oğuz Eİ, Kılıçarslan MA, Özcan M, Ocak M, Bilecenoğlu B, Orhan K. Evaluation of Denture Base Adaptation Fabricated Using Conventional, Subtractive, and Additive Technologies: A Volumetric Micro-Computed Tomography Analysis. J Prosthodont 2021;30(3):257-263.
38. Donovan TE, Chee WWL. A review of contemporary impression materials and techniques. Dent Clin North Am. 2004;48(2):vi-vii,445-470.
39. Yuzbasioglu E, Kurt H, Turunc R, Bilir H. Comparison of digital and conventional impression techniques: evaluation of patients' perception, treatment comfort, effectiveness and clinical outcomes. BMC Oral Health. 2014;14:10.
40. Rhee Y-K, Huh Y-H, Cho L-R, Park C-J. Comparison of intraoral scanning and conventional impression techniques using 3-dimensional superimposition. J Adv Prosthodont. 2015;7(6):460-467.
41. Li Y-X, Bai Y-X, Wei C-F. Three-dimensional digital dental model based on micro-CT. Zhonghua Kou Qiang Yi Xue Za Zhi. 2011;46(1):47-49.
42. Kim C, Baek SH, Lee T, Go J, Kim SY, Cho S. Efficient digitalization method for dental restorations using micro-CT data. Sci Rep. 2017;7:44577.
43. Hamm J, Berndt E-U, Beuer F, Zachriat C. Evaluation of model materials for CAD/CAM in vitro studies. Int J Comput Dent. 2020;23(1):49-56.
44. Walker CG, Ito Y, Dangaria S, Luan X, Diekwisch TGH. RANKL, osteopontin, and osteoclast homeostasis in a hyperocclusion mouse model. Eur J Oral Sci. 2008;116(4):312-318.
45. Lee J-H, Kim H-J, Yun J-H. Three-dimensional microstructure of human alveolar trabecular bone: a micro-computed tomography study. J Periodontal İmplant Sci. 2017;47(1):20-29.
46. Kim T, Lee W, Baek S-H, Pyo S, Kook Y-A, Bayome M, et al. Effects of alveolar bone displacement with segmental osteotomy: micro-CT and histomorphometric analysis in rats. Braz Oral Res. 2016;30(1):e132.
47. Tsutsumi T, Kajiya H, Tsuzuki T, Goto KT, Okabe K, Takahashi Y. Micro-computed tomography for evaluating alveolar bone resorption induced by hyperocclusion. J Prosthodont Res. 2018;62(3):298-302.
48. Zhang Y, Xu X, Zhou P, Liu Q, Zhang M, Yang H et al. Elder Mice Exhibit More Severe Degeneration and Milder Regeneration in Temporomandibular Joints Subjected to Bilateral Anterior Crossbite. Front Physiol. 2021;12:750468.
49. Peters OA, Peters CI, Schonenberger K, Barbakow F. ProTaper rotary root canal preparation: effects of canal anatomy on final shape analysed by micro CT. Int Endod J. 2003;36(2):86-92.
50. Ikram O, Patel S, Sauro S, Mannocci F. Micro-computed tomography of tooth tissue volume changes following endodontic procedures and post space preparation. Int Endod J. 2009;42(12):1071-1076.
51. Kim JJ, Alapati S, Knoernschild KL, Jeong YH, Kim DG, Lee DJ. Micro-Computed Tomography of Tooth Volume Changes Following Post Removal. J Prosthodont. 2017;26(6):522-528.
52. Chang Y-H, Wang H-W, Lin P-H, Lin C-L. Evaluation of early resin luting cement damage induced by voids around a circular fiber post in a root canal treated premolar by integrating micro-CT, finite element analysis and fatigue testing. Dent Mater. 2018;34(7):1082-1088.
53. Soares AP, Bitter K, Lagrange A, Rack A, Shemesh H, Zaslansky P. Gaps at the interface between dentine and self-adhesive resin cement in post-endodontic restorations quantified in 3D by phase contrast-enhanced micro-CT. Int Endod J. 2020;53(3):392-402.
54. Çehreli MC, Akça K, İplikçioğlu H, Şahin S. Dynamic fatigue resistance of implant–abutment junction in an internally notched morse-taper oral implant: influence of abutment design. Clin Oral Implants Res. 2004;15(4):459-465.
55. Khraisat A, Stegaroiu R, Nomura S, Miyakawa O. Fatigue resistance of two implant/abutment joint designs. J Prosthet Dent. 2002;88(6):604-610.
56. Schmitt CM, Nogueira-Filho G, Tenenbaum HC, Lai JY, Brito C, Döring H, et al. Performance of conical abutment (Morse Taper) connection implants: a systematic review. J Biomed Mater Res A. 2014;102(2):552-574.
57. Cha H-S, Kim Y-S, Jeon J-H, Lee J-H. Cumulative survival rate and complication rates of single-tooth implant; focused on the coronal fracture of fixture in the internal connection implant. J Oral Rehabil. 2013;40(8):595-602.
58. Mombelli A, Müller N, Cionca N. The epidemiology of peri-implantitis. Clin Oral İmplants Res. 2012;23 Suppl 6:67-76.
59. Wilson Jr TG, Valderrama P, Burbano M, Blansett J, Levine R, Kessler H, et al. Foreign bodies associated with peri-implantitis human biopsies. J Periodontol. 2015;86(1):9-15.
60. Karl M, Taylor TD. Parameters determining micromotion at the implant-abutment interface. Int J Oral Maxillofac Implants. 2014;29(6):1338-1347.
61. Stimmelmayr M, Edelhoff D, Güth J-F, Erdelt K, Happe A, Beuer F. Wear at the titanium–titanium and the titanium–zirconia

implant–abutment interface: A comparative in vitro study. Dent Mater. 2012;28(12):1215-1220.

**62.** Blum K, Wiest W, Fella C, Balles A, Dittmann J, Rack A, et al. Fatigue induced changes in conical implant–abutment connections. Dent Mater. 2015;31(11):1415-1426.

**63.** Rezende CEE, Griggs JA, Duan Y, Mushashe AM, Nolasco GMC, et al. An indirect method to measure abutment screw preload: A pilot study based on micro-CT scanning. Braz Dent J. 2015;26(6):596-601.

**64.** Kapishnikov S, Gadyukov A, Chaushu G, Chaushu L. Micro-CT Analysis of Microgap at a Novel Two-Piece Dental Implant Comprising a Replaceable Sleeve In Vitro. Intl J Oral Maxillofac Implants. 2021;36(3):451-459.

**65.** Bagegni A, Zabler S, Nelson K, Rack A, Spies BC, Vach K, et al. Synchrotron-based micro computed tomography investigation of the implant-abutment fatigue-induced microgap changes. J Mech Behav Biomed Mater. 2021;116:104330.

**66.** Bergamo ETP, Campos TMB, Lopes ACO, Cardoso KB, Gouvea MVR, de Araújo-Júnior ENS, et al. Hydrothermal aging affects the three-dimensional fit and fatigue lifetime of zirconia abutments. J Mech Behav Biomed Mater. 2021;124:104832.

**67.** Verdonschot N, Fennis WM, Kuijs RH, Stolk J, Kreulen CM, Creugers NH. Generation of 3-D finite element models of restored human teeth using micro-CT techniques. Int J Prosthodont. 2001;14(4):310-315.

**68.** Magne P. Efficient 3D finite element analysis of dental restorative procedures using micro-CT data. Dent Mater. 2007;23(5):539-548.

**69.** Della Bona A, Borba M, Benetti P, Duan Y, Griggs JA. Three-dimensional finite element modelling of all-ceramic restorations based on micro-CT. J Dent. 2013;41(5):412-419.

**70.** Marcián P, Wolff J, Horáčková L, Kaiser J, Zikmund T, Borák L. Micro finite element analysis of dental implants under different loading conditions. Comput Biol Med. 2018;96:157-165.

**71.** Ausiello P, Tribst JPM, Ventre M, Salvati E, di Lauro AE, Martorelli M, et al. The role of cortical zone level and prosthetic platform angle in dental implant mechanical response: A 3D finite element analysis. Dent Mater. 2021;37(11):1688-1697.

**72.** Kaigler D, Mooney D. Tissue engineering's impact on dentistry. J Dent Educ. 2001;65(5):456-462.

**73.** Hollister SJ, Lin CY, Saito E, Lin CY, Schek RD, Taboas JM, et al. Engineering craniofacial scaffolds. Orthod Craniofac Res. 2005;8(3):162-173.

**74.** Hatamleh MM, Watts DC. Porosity and color of maxillofacial silicone elastomer. J Prosthodont. 2011;20(1):60-66.

**75.** Artopoulou II, Chambers MS, Eliades G. Porosity of maxillofacial silicone elastomers and microleakage pattern of the commercially pure Ti-silicone elastomer interface after hydrothermal cycling. J Prosthet Dent. 2016;116(6):937-942.

Cumhuriyet Dental Journal, 26(1): 87-96, 2023
DOI: https://doi.org/10.7126/cumudj. 1236585

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 | Available online, ISSN: 1302-5805 e-ISSN: 2146-2852 | Publisher: Sivas Cumhuriyet Üniversitesi

# General Consideration of Post Systems

**Mustafa Kocacıklı**[1-a*]

[1] Department of Prosthodontics, Faculty of Dentistry, Gazi University, Ankara, Türkiye.
*Corresponding author

**Review**

*History*

*Received: 16/01/2023*
*Accepted: 31/01/2023*

**ABSTRACT**

Endodontic treatment needed teeth are generally with a presence of carious tissue or have had large restorations in the past. Sometimes the defects cannot be treated with restorative procedures alone, they need the addition of a technique that involves the pulp chamber, such as additional root canal treatment to the teeth. The requirement for extra retention for the core structure and coronal restoration to be performed therefore makes posts essential components in the roots of teeth with structural damage.

More often than not endodontically treated teeth remain relatively intact after conservative endodontic treatment. Endodontically treated teeth become more brittle for some reasons and one of the reasons is the masticatory function of the jaws. As a result of this known phenomenon, dental professionals have been looking for strategies to prevent pulpless teeth from breaking. Restoration and reinforcement of pulpless teeth is a crucial preventative step in endodontic therapy. A post may be used in the root of a structurally damaged tooth in which additional retention is needed for the core and coronal restoration. A widely used technique for repairing teeth that have undergone endodontic treatment is post and cores.

Retention applied onto the root thorough final restoration using the post and core restoration as a substructure. Therefore, post placement in the root is crucial. In order to ensure retention for a fixed restoration, endodontically treated teeth are frequently treated with posts and cores. Teeth that had gone through endodontic treatment often suffer from severe coronal damage. In order to ensure retention for full or partial coverage restoration, these teeth may require a coronal substructure or core for retention of a full or partial bonding restoration. Generally, primary retention feature of a core is an intraradicular post. Posts and cores are routinely used for endodontically treated teeth. This article provides a review presentation about utilization of post systems on the pulpless tooth.

***Keywords:*** Root Canal Treatment, Post Implementation, Post Classification, Prefabricated Post, Advantages of Post, Post Indication.

# Post Sistemlerine Genel Bakış: Derleme

*Süreç*

*Geliş: 16/01/2023*
*Kabul: 31/01/2023*

**ÖZ**

Endodontik açıdan tedavi gerektiren dişler sıklıkla büyük miktarda çürük doku içeren, ya da daha önceden üzerinde büyük restorasyonlar bulunan dişlerdir. Bu durumdaki dişlere bir de ilave kök kanal tedavisi gibi pulpa odasını da içine alan bir işlem eklendiğinde bazen tekbaşlarına restoratif işlemlerle eksiklikler yerine konulamazlar. O zaman postlar, yapısal olarak hasar görmüş dişlerin köklerinde, yapılacak olan kor yapı ve koronal restorasyon için ek retansiyon ihtiyacını sağlamak amacıyla vazgeçilmez unsurlardır.

Endodontik tedavi görmüş dişlerde koronal hasar sıklıkla şiddetlidir. Bu dişler, tam veya kısmi bir kaplama restorasyonunun tutulması için bir koronal altyapı veya core gerektirebilir. Postlar ve corelar rutin olarak endodontik dişleri restore etmek için kullanılır. Kök kanal tedavisi görmüş dişler, konservatif endodontik tedaviden sonra sıklıkla nispeten sağlam kalır. Endodontik tedavi görmüş dişlerin sağlıklı dişlere göre daha kırılgan olduğu gösterilmemesine rağmen, pulpasız dişlerin çiğneme sırasında kırıldığı bilinmektedir. Diş hekimleri, bu deneyimin bir sonucu olarak pulpasız dişlerin kırılmasını önlemek için strateji aradılar. Endodontik tedavide, pulpasız dişlerin restorasyonu ve güçlendirilmesi çok önemli bir koruyucu adımdır. Postlar ileri derecede hasar görmüş olan endodontik tedavili dişlerde üzerine yapılacak olan kor yapı ve protetik restorasyona dayanak sağlamak amacı ile yerleştirilirler. Endodontik tedavi görmüş dişleri onarmak için yaygın olarak kullanılan bir teknik, post ve corelardır. Son restorasyonun köke retansiyonu, alt yapı olarak post ve core restorasyon kullanılarak yapılabilir. Bu nedenle, postu köke yerleştirmek çok önemlidir. Sabit bir restorasyon için retansiyonu sağlamak amacıyla, endodontik tedavi görmüş dişler sıklıkla post ve corelarla tedavi edilir. Bir core'un birincil tutucu özelliği genellikle bir intraradiküler posttur. Bu makale post sistemlerinin pulpasız dişlerde kullanımını gözden geçirerek sunmaktadır.

***Anahtar Kelimeler:*** Kanal Tedavisi, Post Uygulaması, Post Sınıflaması, Prefabrike Postlar, Post Avantajları, Post Endikasyonları.



[a] dr.dt.mustafa@gmail.com https://orcid.org/0000-0002-2417-588X

*How to Cite:* Kocacıklı M. (2023) General Consideration of Post Systems, Cumhuriyet Dental Journal, 26(1):87-96.

## Introduction

A tooth that maintains crown integrity with no structural defects has sufficient strength against masticatory forces. However, if a certain tooth has undergone root canal treatment because of trauma or caries, its dentin integrity would be weakened due to excessive loss of material and cannot provide sufficient strength against functional forces.[1] Supporting such a tooth with a post system, ensures that the survival time of the teeth in mouth.[2]

Endodontically treated teeth with excessive loss of material in the crown section are observed to suffer more fractures against functional forces in comparison to vital teeth.[3,4] It has been shown in literature that stress resistance of these teeth decreases while brittleness increases, both caused by insufficient moisture and material loss in dentin.[3]

Tooth supported crown and bridge prosthesis have biomechanical and physiological advantages over mucosa-supported prostheses. Therefore, oral rehabilitation based on tooth-supported occlusion is preferred. Most significant benefits include masticatory muscle efficiency and tooth stabilization, as well as preservation of vertical size and supporting tissue. Therefore, even when excessive crown destruction is observed, remaining tooth structure utilization should be maximized.[5]

Endodontically treated teeth may have lost a significant portion of their existing crown structure due to an access cavity, an existing restoration, or caries, which may be the main cause of endodontic problems. In many cases, crown section support from root canals may be required to ensure durability and retention of restoration. Post and core systems are the significant parts of this procedure.[6]

Problems may arise in the treatment of excessively tapered and wide canals caused by incomplete root development, endodontic restorations, pulp pathologies, caries, or idiopathic reasons. Utilizing traditional, tapered, or cast posts may cause fractures in the coronal section, already weakened by wedge effect. Crown restoration conducted by supporting the weak root through the canal with appropriate adhesives and post-core procedures may help prolong teeth functionality in the mouth. Many researchers have advocated that composite resins are similarly suitable materials for core and post construction as well as traditional metallic root posts, and reported successful results.[7]

The idea of traditional posts and plastic filler material utilization to replace fabricated post and core systems was introduced in 1960s.[8] However, it has been reported that post-core systems have been used in dentistry for more than 250 years.[9]

In addition tooth structure loss caused by endodontic procedures, subsequent material removal for crown preparation often results in inadequate crown support. Replacing lost tooth structure with a core made of moldable filling materials can provide adequate support for the crown. However, when the remaining tooth structure is insufficient for crown retention, a post and core are often required.[10,11]

Schillingburg *et al.*[11] suggested that prefabricated post and core systems have been the most commonly used systems after 80s to provide restoration for support.

Indications of Post Core Restorations[12]:

1- In cases where observed crown section loss cannot be repaired by pinned core procedure or utilizing undercut, auxiliary cavities, retaining grooves, acid etching or bonding methods,
2- In cases where pulp integrity is impaired by axial or occlusal reconstruction of the malposed tooth,
3- In cases where crown/root ratio of teeth with weak periodontal support needs to be strengthened with the help of endodontic supports,
4- In cases where bar and stud attachments require root retention in overdenture applications,
5- In cases of severely defected teeth with pulp prognosis suspicion, as post-restoration endodontic treatment will be difficult otherwise.

Advantages of Post Core Application[12]:

A- Two-stage restoration is utilized to support the cast superstructure of root canal treated teeth.
1- When prosthetic restoration fails partially or marginally, treatment can proceed without intra-coronal restoration renewal.
2- When posts are not in cast form, undercuts on teeth can be filled, which could help preserve the tooth structure to be removed for cast superstructure restoration.
3- Post-core structure reduces the amount of cast alloy used in the final restoration.
B- Posts can be utilized for temporary restoration during periodontal and orthodontic treatment applied to teeth with previous root canal treatment.
C- Posts establish connection between root and crown.
D- Take into account the advantages of use when tooth structure is insufficient locally, in terms of size, or in contrast to the quantity of displacing forces. Notable indications include lost or insufficient pulp chamber wall, or lack of opposing walls to support one another.

Disadvantages of Posts[13]:

1- Post is placed through additional operation.
2- Preparations for post placement on tooth could cause more material loss in the tooth.
3- If the cavity required for post construction is not smooth enough or excessively wide, the core will be inadequate for restoration, which may result in failure to cement post core restoration onto cavity. Also due to this problem cementation and leakage problems may occur.
4- Using posts in restoration that are not suited for repeated root canal procedures may result in a number of complications or prevent retreatment.

Requirements for Post Placement Teeth:[13,14]

1- A good apical seal must be achieved.
2- There should be no sensitivity in pressure.
3- There should be no exudation.

4- Use gutta-percha restorative material to completely fill without gaps.
5- There should be no sign of infection on lateral or apical periodontium.
6- Repeat incomplete canal fillings; in case of any doubt, monitor the tooth until you are confident. Post should only be placed after all suspicions are clarified.
7- Remaining clinical crown length and remaining apical distance after post placement should be taken into consideration.
8- Inspect for any potential subgingival caries.
9- Lamina dura continuity and bone must be evaluated for resorption.
10- Evaluate root canal morphology for potential complications before opening post cavity.
11- Occlusal relationship and undesirable mastication relations should be taken into consideration.

There are many classifications about posts in modern day.

According to the classical classification, posts are divided into two classes:[15,16]

1- Conventional posts made by casting method: this is the traditional post type produced by taking measurements through direct or indirect methods, preparing a model, and finally casting.
2- Prefabricated standard posts: prefabricated standard posts are also divided into two classes based on application method:[5,16]
   A- Passive posts: this is the type of post cemented directly into prepared post cavity by its own drills, without any requirement to screw into the root canal. These posts can be either grooved or flat. Two types are defined based on shape:
1- Parallel-edged,
2- Tapered.
   B- Active posts:
1- Threaded parallel-edged posts with a special guide drill Flexipost: A groove is created by using a lead bur followed by a guide bur, after which the post is screwed clockwise into the canal.[5,16]
2- Directly screwed self-tapping threaded parallel-edged posts: Screwed clockwise into root prepared with a guide bur applicable to selected post diameter.[5,16]
3- Directly screwed self-tapping threaded tapered posts: These may cause more root fractures and cracks than parallel-edged ones.

Methods Used for Restoration of Teeth with Previous Root Canal Treatment and Excessive Material Loss[2]:

   A- Cast post-core: Prepared by direct or indirect method. Direct method features wax or acrylic model prepared in mouth, and indirect method on die.[2]
   B- Amalgam or composite resin coronal-radicular core for posterior teeth: There are two techniques:
1- Post-core and pin supported amalgam or composite resin core:[2,17] Entry path for post-core may be problematic in multi-rooted teeth with divergent canals. In this method, posts are cast separately and inserted into the canal through the opening in core during cementation.
   C- Coronal-radicular amalgam or composite resin post-core:[18] In this method, post and core are prepared together by placing amalgam or composite in the pulp chamber and coronal part of the tooth from the pulp chamber to the canals in molar teeth.
   D- Prefabricated post with amalgam or composite core: This commonly preferred system involves amalgam or composite resin core structure shaped by direct method following the application of prefabricated standard posts onto the tooth by direct method.

Sorensen and Martinoff classify posts as follows:[18]

1- Threaded metal posts
a- Obturation screws e.g.: FKG
b- Dentatus screw posts e.g.: Unitek, Swedia, Medidenta
c- Radix-Anchors
d- Flexipost
e- Kurer Posts: Anchor, fin-lock, crown saver, press stud

2- Non-threaded metal posts:
a- Endopost
b- Charlton crown post kit
c- Post kits
d- Nu-bond post

3- Plastic models:
a- Endowels
b- Norm plastic pins
c- Standard plastic pins

4- Combination kits:
a- C-I kit
b- PD posts
c- Colorama
d- Para-post

Mumford and Jedynakiewicz divide prefabricated posts into 5 main groups:[19]

1. Charlton System: Features a directly inserted stainless steel post and a steel core attached to it. The core is appropriately prepared outside the mouth and mounted into the mouth. May cause excessive tooth tissue loss during adaptation.
2. Kurer System: A threaded post system which can be applied with or without a core. Preparing the flat surface on cervical region of the tooth for the core after parallel-edged post cavity prepared with a reamer will cause loss of last remaining tissue of the crown, which is the primary disadvantage of this system
3. Schenker System: Utilized posts feature parallel edges and two different diameters. The diameter is narrower in the apical part. Difficulties may be encountered while preparing the socket and mounting the post.
4. Dentine Screwed Systems: Posts are screwed onto dentin in the canal with a hand tool. Costs less and can

be applied rather quickly. May create stress which could lead to root cracks and fractures.

5. Parapost System: It is a popular post system which can be used in many cases. It is a parallel-edged and grooved system. Its longitudinal groove causes excess cement to come out.

Caputo and Standlee classify posts in two different groups based on surface properties and shapes:[20]

A- Tapered and Flat Surface Posts: These include Kerr Endopost, Mooser Post, Unitek Post, Schenker Post, Stutz Post systems. They are the oldest and most commonly used posts. As tapered form is the natural form of canal, preparation and cementation is easy. Cement escape is also a possibility, so they might cause minimum hydrostatic pressure. A major disadvantage is that wedge effect may cause root fractures.

B- Parallel Edged Posts: Whaledent Parapost, Unitek Charlton Post, Degussa Post systems are included in this group. Parallel-edged posts may not always be available in narrow, tapered or non-straight root canals; canal preparation requires more dentin removal apically. Not suitable for mandibular incisors, mesial roots of molars, and upper first molars. Yields better results in long, wide-rooted teeth with a wide dentin wall. High probability of root fracture should be kept in mind when using such posts.[5,15,20,21]

There are two types:

1- Parallel-edged posts with flat surface: Parallel-edged posts with tapered end have been developed to increase normally low retention. However, the tapered end acts like a wedge at the root and causes fatigue.[5,15,20]

2- Parallel-edged posts with grooved surface: Most deny cement escape, which makes placement with hydrostatic pressure more difficult. While cement escape might occur if the canal is widened excessively, this would decrease retention as the space between post and canal would also be widened.[5,19,22]

Walton and Trobinejad[16] showed that these posts distribute stress more evenly than tapered posts with flat surfaces and do not trigger a wedge effect. Caputo and Standlee showed that these posts distribute stress equally between post-cement-supporting tooth tissue in the face of compressive loads.[20]

C- Tapered Posts with Threaded Surface: Some examples of this system include Blue Island, Buffalo, and Dentatus Post. Mount post by turning it clockwise on its own axis. Triggers great stress on root during application. Root fractures may also occur with masticatory pressure. Stress concentration is higher in short length than in long length. This is the post group that causes the most root fractures.[19,20,23,24]

D- Parallel Edged Posts with Threaded Surface: Kurer Anker and Radix Anker post systems are in this group. Dentin usage is increased for mechanical retention. These are mounted on canals prepared by special burs that create a ledge form.[20] Caputo and Standlee determined that when grooves are sharper and fewer in numbers, there would be less stress formation around them.[20] They concluded that Radix Anker posts create less stress than Kurer Anker posts.

Caputo and Standlee and Cohen *et al.* have shown that cylindrical posts with threaded surfaces are the most retentive posts. However, thick diameter may cause root fracture and perforation.[15,20]

Standlee and Lui reported that stress distribution and retention properties of all post groups are related to post fully adapting on the canal.[20,22]

Current classification[25]

A. Classification of Cast Post:

I. According to type of alloy.

1. Gold alloy
2. Chrome-Cobalt alloy
3. Nickel-Chromium alloy

II. According to number of Post.

1. Single Post
2. Multiple Post
   a.One Piece Post
   b.Two Piece Post

B. Classification of Prefabricated Post

I. According to Taper

1. Parallel
2. Tapered
3. Parallel Tapered

II. According to surface character

1. Smooth
2. Serrated
3. Self threading

III. According to fit

1. Active
2. Pasive

IV. According to material

1. Metallic
   i. Titanium
   ii. Stainless steel
   iii. Brass
2. Non-Metallic*
   i. Non-Esthetic
   a. Carbon fibre post
   ii. Esthetic Post
   a. Polyethelene fibre
   b. Glass fibre
   c. Quartz
   d. Ceramic

V.According to light transmission
1. Light transmitting
2. Non-Light transmitting

VI.According to Vent
1. With Vent
2. Without Vent

VII.According to Monoblock formation
1. Monobloc formation
2. No Monobloc formation

Monoblock system: This concept gained popularity in 1996 when epoxy resin posts reinforced with carbon fiber were mechanically connected to root dentin as a homogenous monoblock. To create a three-dimensional seal, the root dentin, canal walls, sealer, and obturating material should all attach to one another and come together to form a solid, homogenous unit. The phrase "monoblock effect" refers to this.[26]

Depending on the number of contacts between the bonding substrate and the core bulk material, replacement monoblocks that are produced in the root canals may be categorized as primary, secondary, or tertiary. In a primary monoblock, the root canal wall and the core material make just one circumferential contact. Secondary monoblocks include two circumferential contacts between the cement and the dentin and the cement and the core material. Then a third circumferential contact is introduced between the abutment material and the bonding substrate, a tertiary monoblock is produced. Fiber posts with a silicate coating or an unpolymerized resin composite known as tertiary monoblocks are used to fill large canal gaps that cannot support conventional fiber posts.[26]

Post systems will continue to play a significant role in the restoration of teeth that have undergone endodontic treatment. Meta-analysis of long-term clinical investigations has revealed that fiber posts have greater success rates than other post systems.[27,28] Due to their physical similarities to dentin, ability to evenly distribute functional stresses across the root surface, ease of application, and aesthetic compatibility with neighboring tissues and all-ceramic restorations, fiber-reinforced composite post systems are frequently preferred by clinicians. To demonstrate whether fiber reinforced composite post system is more effective and favorable in clinical applications, further well-designed in vitro and in vivo investigations are required.[29]

Primary purpose of every single post is to provide retention for the core.[30] Following factors affect posts' retention.[11,31-33]

- Canal shape,
- Post size length-diameter,
- Form and surface features,
- Adhesive materials.

There are a number of different suggestions on optimal post length[5,13,24,34,35], which can be summarized as follows:
1. It should be greater than or equal to length of clinical crown,
2. It should be half the size of the root,
3. It should be equal to length of anatomical crown,
4. It should be half the distance between apex and alveolar crest,
5. It should be long enough to leave 3-5 mm of canal filling material at the root tip,
6. It should be 2/3 of the remaining root length,
7. It should be 3/4 or more of the root.

Post length: Studies have shown that retention and post length are positively correlated.[36,37] However, excessive increase in post length may lead to disruption of apical occlusion and/or apical region may be curved, which could lead to perforations.[13]

According to Weine, average post length for maxillary central incisor should be 10.5 mm, and average post length for maxillary canine should be 9.5 mm.[38] According to Amartnath *et al.*, the post material and post length had a significant impact on the fracture resistance of teeth that had undergone endodontic treatment. After increasing the fracture resistance of the teeth by about two-thirds of the root length after being rebuilt with posts, post length started to decline. With an increase in FP length, the teeth's fracture resistance increased correspondingly.[39]

Studies have shown that, although threaded posts maintain retention advantages, they also cause stress concentration at root tip and lateral walls during mounting and may cause root fractures around crown-root border. Hence when choosing a post, make sure root diameter and post diameter are compatible with each other.[5,15,20]

A number of factors affect post retention[11,31,32,40], including canal shape, post size length-diameter, post shape, surface features, and adhesive materials.

Studies have shown that retention and post length are positively correlated.[36,37] However, excessive increase in post length may lead to disruption of apical occlusion and/or apical region may be curved, which could lead to perforations.[13]

Krupp et al.[41] reported that the most important factor affecting post retention was post depth. Rueping et al.[42] reported that increasing post length from 5 mm to 8 mm increased retention 1.23 times. They also reported that increasing post length from 7 mm to 11 mm increased post retention by 30%, and increasing post length from 9 mm to 11 mm increased post retention by 24%. Sidoli *et al.*[43] reported in their photoelastic study that stress concentrations could be decreased by increasing post length.

Post Diameter: While according to some researchers post diameter is insignificant for retention another study demonstrated that retention increased by 24% when diameter was increased in parallel-edged posts tapering towards the tip, and thus in conclusion they suggested that post diameter should be 1/3 of root diameter.[33,37] Caputo and Standlee argue for a dentin thickness of at least 1 mm around the canal.[20] It was observed that stress increases when post diameter is increased, and stress on dentin and tooth supporting structure decreases by using posts smaller in diameter.[44] Ideally, post diameter should be determined

in accordance with anatomy of root canal without intact tooth tissue loss.[35] In a study conducted by using different post diameters, Hanson and Caputo reported that medium-sized 0.6-inch diameter posts were more retentive than 0.5 and 0.7-inch diameter posts.[45] Another study reported that minimizing post diameter would not only preserve tooth structure, but also reduce root fracture risk.[36] Weine *et al.*[38] determined that increasing post diameter does not strengthen tooth structure nor increase retention, and that stronger retention could be achieved by increasing post length instead of diameter. Tjan and Whang, reported that over-expanded canals would cause weaker teeth due dentin tissue loss, and may lead to fractures as a result of incoming forces.[33] According to Hudis and Goldstein, there are 3 primary principles for preparing post cavity for teeth with previous root canal treatment:[35]

1- Conservative approach: argues that prepared post space should be as small as possible.
2- Proportional approach: argues that apical section of the post should be 1/3 of the diameter at the point it meets the root.
3- Protective approach: argues that the dentin around the post should be 1 mm thick all around at minimum.

Surface Characteristics of Posts: It has been proven that threaded or roughened posts have stronger retentive properties than smooth ones. Tapered posts are reported to bear stronger retention by creating small grooves on post surface and in the canal. Standlee *et al.*[46] reported that post shape affects retention more than post length. According to the study, threaded posts are the most retentive, followed by parallel-edged posts, and tapered posts are the least retentive ones. One study showed that post shape is the most important factor in post retention, with parallel sided posts being 4.5 times more retentive than tapered ones. Snoek and Creugers conducted a study to determine whether aluminum or zirconium oxide coatings could improve retention of non-threaded titanium posts.[47] They concluded that aluminum or zirconium oxide coated post surface with Panavia 21 adhesive created same level of bonding as threaded posts. Mansfield *et al.*[48] found that retention values of glass ionomer cement and resin cement modified with micro etching increased in tensile test performed with posts.

Prioritized posts with threads do not contact the canal wall, but retention reliability on cement is considered passive, while mechanically treated dentin is considered active. Active or threaded posts are more retentive than passive conforming posts, and parallel-edged posts are more retentive than tapered posts.[11]

In their recent study on post retention, Standlee and Caputo showed that parallel-edged threaded posts are more retentive than parallel-edged serrated posts, and parallel-edged posts are more retentive than tapered smooth surface posts.[37]

Active posts with dentin-inserted threads create more stress during production and mounting than other forms.[13] One step backward rotation of active posts, limited by the number of post grooves in the post canals prior to compression, is used in some techniques to remove stress. Threaded tapered post creates the greatest level of stress among all post designs. 49 Passive tapered posts contain an escape route and create a little stress during application. However, tapered posts, whether active or passive, can create compression during mounting.[10,31,50,51] In contrast, a serrated post with parallel-edged cement escape holes distributes stress more evenly than other designs.[13,31,50,51]

Post choice depends on tooth root anatomy and shape of prepared canal.[49] Tapered posts fit more easily into endodontically prepared canals, and are more conservative in their adaptation to tooth structure.[13]

Another significant expectation from posts and cores is to make sure the lateral forces on remaining tooth structure are distributed over a wider area.[13] Posts distribute forces on them according to their shape, diameter and length. While tapered posts are considered to increase root fracture risk through wedge effect, parallel-edged posts reduce this risk. Posts mounted solely with cement distribute the forces on them better. Cement creates a buffer between the tooth and the post. Same buffer feature can also be observed in threaded posts. Increasing post diameter and length helps distribute occlusal forces better. However, optimum apical dentin thickness must be maintained while increasing the diameter.[24]

Research on the effect of post shape on stress distribution has revealed the following results:[13]

1- Highest levels stress occurs at the apex of tooth cervical region. Therefore, dentin in this section should be preserved as much as possible.
2- Stress decreases as the post length increases.
3- Posts with parallel edges can distribute stresses better than tapered posts.
4- Sharp edges and angles should be avoided due to high stress that can occur with overload.
5- Very high stress values can occur during placement of posts with parallel edges with no cement escape route.
6- Threaded posts can reach high stress values during mounting and utilization.

The Importance of Coronal Tooth Structure in Post Applications: Cohen and Burns argue that post choice should be based on amount of remaining dentin, and classify accordingly[21] According to this;

1- Cases where the crown is completely preserved and access cavity is shaped between crown structures: In such cases, post application is not necessary. Trope *et al.*[52] reported that posts applied in such cases increase fragility.
2- Cases where at least half of the crown remains: A post suitable for root length is selected Parapost, Flexi-Post, BCH post, CI post, Endopost, Boston post systems. The canal is prepared with a guide bur. After the necessary procedures for core retention are performed, the post is cemented. Restoration is then completed with the crown finished on shaped core material.
3- When less than half of the crown remains and there is no dentin support: Any post system can be used. Two

methods can be used to prepare the core. In the direct method, modelling is conducted in the mouth, and removed together with the post and sent to casting. In the indirect method, core is modelled according to measurements taken while post is in the canal, and sent to casting. Post alloy and core alloy must be compatible, or corrosion will cause negative effects on the system.

Ferrule Effect: The metal ring that surrounds the cervical region of the tooth is a significant element in post application, preventing root fracture and supporting the crown. Extending as far as possible in the direction of the gingiva on the core, the ring will surround the root and prevent vertical fractures. It will also prevent the post from rotating due to horizontal forces. It is reported that this metal ring creating the ferrule effect should surround the tooth with a width of at least 1-2 mm, and a parallel sidewall form ending in solid tooth structure.[5,14]

For teeth with fillings at the root, a 1.5–2 mm circumferential ferrule is advised. An partial ferrule, however, is seen to be preferable to a completely absent ferrule if the clinical circumstance does not allow for a circumferential ferrule.[53] To reduce the risk of unfavorable failures, it is advised to utilize glass fiber posts with ferrule heights of at least 1 mm.[54] Different research that were considered have different definitions of ferrule. The ferrule's height was specified as 2 mm by Cagidiaco *et al.*, but Signore *et al.*[55,56] described it as a circumferential collar of dentine with a height of at least 1.5 mm but not more than 2 mm in teeth that had completely lost their coronal walls. In both investigations, there were a number of instances where the loss of tooth structure was not uniform, but the ferrule height was never less than 1 mm. Ferrari *et al.*[57,58] defined ferrule as the absence of an axial wall but with at least a 2 mm high collar of dentine that was preserved circumferentially, whereas no-ferrule defined the absence of an axial wall but with less than 2 mm height of dentine but without any description of minimal circumferential dentine. According to their definition, a ferrule's height cannot range from less than 2 mm to as low as the gingival edge.[59]

Physical Properties of Post Materials: Traditional prefabricated posts are made of stainless steel, titanium and its alloys, platinum-gold-palladium, chromium-containing alloys, or brass.[13,24,32] Today, non-metal carbon fiber epoxy posts are finding more and more applications.[13,49]

The modulus of elasticity of metal and the cross-section geometry of the post determine the vertical stiffness. Insufficient vertical stiffness causes deformation against force. Yield strength of post metal must also be high. If the yield strength is low post and core may be deformed, crown margins could be widened, and restoration may fail.[24]

Allergy and sensitivity potential of nickel among post materials is also interesting. Biocompatible titanium appears less radiopaque on radiography than nickel and stainless steel alloys. Radio opacity of titanium posts is similar to that of gutta-percha, and radiographic image may be obscured by other opaque cements. Titanium posts are difficult to distinguish in root canals filled with condensed gutta-percha. According to Alaçam *et al.*[12], although titanium based materials are weaker than nickel chromium alloys, this difference is clinically insignificant.

Titanium, more commonly used in recent years, is only half as durable as steel. Modulus of elasticity for titanium is 15 psi, while that of steel is 28 psi. Both yield strength and tensile strength of titanium are lower than steel. Thus, post strength is sacrificed to use a biocompatible material. As properly mounted posts will not come into contact with living tissue, biocompatibility will not be of much importance.[24]

Corrosion on Posts: Corrosion is responsible for weakening both post and tooth, leading to root fractures. Although ion exchange between different metals titanium, steel, amalgam, gold used to make the post and core is claimed to be the cause of corrosion, it has been recognized that the real cause of corrosion is microleakage.[13]

Modulus of elasticity and corrosion of posts are factors to be considered in metal selection.[11,13,32,50] Titanium alloys have the highest corrosion resistance. However, titanium is much less resistant to fracture than cobalt-chromium-molybdenum or stainless steel. Stainless steel and brass both show low corrosion resistance. Platinum-gold-palladium, cobalt-molybdenum metal alloys and titanium are the most suitable metals for endurance and corrosion resistance.[11,13,32,50] According to Jacobi and Schllingburg, brass is the least preferred alloy because of its low strength and low resistance to corrosion. 49 Nickel-containing alloys are avoided in nickel-sensitive patients.[32]

Effects of Root Morphology on Post Selection: Both internal and external contour of the root influence post selection. All roots end in a narrowing form from cervical region to the apex. Some especially narrow down even more in the apical triad. Using parallel posts on such teeth may cause root perforation, therefore tapered or short parallel posts should be preferred. However, using tapered posts creates a wedge effect via force transfer. In addition, short posts spread the load over a short root area, and thus their stress distributing function is limited.

If the transverse section of the root canal is oval or octagonal, preparing a circular post canal would be difficult. Cast posts may help protect tooth structures while they also require less apical preparation. Coronal section of cast posts also provide an anti-rotational feature. If a root canal can be opened to be equal to or longer than the clinical crown of the tooth, coronal core and combined parallel post will be the best option.[16,24]

Preparation Geometry: Root canals with a circular cross-section makes post preparation comfortable, whereas root canals with an elliptical cross-section require root canal preparation to be tapered, usually at 6°, to eliminate unwanted undercuts.

Optimal post geometry should include high-strength, corrosion-resistant material, with adequate retention and ability to distribute forces appropriately, minimizing the risk of perforation and tooth structure loss during application.[13,32,37,50]

Despite clear disadvantages, researchers defend placing posts on endodontically treated teeth. However, some studies have reported that placing posts on teeth with previous root canal treatment does not strengthen tooth

structure.[15,20,52,60-62] When tooth is overloaded, stress is placed on lingual and facial part of the root, while the post inside the root is minimally affected by this stress.[18,52] Therefore, it is not effective in preventing fractures. 13 There are also those who argue the opposite of this thesis.[63,64]

Prefabricated post and core system consists of two parts, the post and the core, the latter being a moldable filling material. However, the system cannot exist without an adhesive cement to improve retention and help sealing along the canal. Regardless of surface configuration and features, adhesive cement is used when placing posts. Thus we conclude all three components of a prefabricated post and core system: prefabricated post, plastic core material, adhesive cement.

### *Core Materials*

Cores are restorative segments that are removed from the tooth's post structure where coronal tooth tissues have been destroyed. The chosen post system and the tooth tissue should be compatible with the optimal core material.

While the post and core are cast together and assessed as a unit in cast post-core restorations, core materials for prefabricated posts might include amalgam, glass ionomer cement, ceramic materials, and composite resins. Core materials should have appropriate mechanical qualities including mechanical resistance, dimensional stability, and elastic modulus, as well as be simple to use. The core material of choice has an impact on the stress distribution seen in the post-core system.[65]

For ultimate repair, the core provides retention and resistance. For prefabricated resin composite and glass ionomer cement post and core systems, amalgam is used to shape the core.[10,11] Amalgam is quite simple to manipulate and has a high compressive strength and minimal microleakage. As a temporary repair in situations when the cast superstructure is delayed, amalgam offers acceptable wear resistance. Their drawbacks, however, are their long-term hardness and lack of adherence to the tooth structure.[10,32,66] Despite this, fast-curing high-copper amalgam has low tensile strength and sufficient compressive strength within the first hour of preparation.[67] Amalgam cores that are not prepared properly are prone to breakage.

Studies on the effectiveness of dentin bonding agents used with amalgam have resulted in a variety of findings. Mahler *et al.*[68] observed no distinction in the bond strength of bonded and unbonded amalgam in two excellent clinical trials. While Donald *et al.*[69,70] discovered in a laboratory investigation that the use of adhesive bonding with an amalgam core improves the amalgam's resistance to brittleness, Belcher and Stewart developed restorations for retention and discovered an amalgam adhesive that may be clinically useful.

Despite the development of amalgam bonding systems, they are unable to achieve the same amount of bonding as composite bonding systems. Some studies indicate that the advantages of resin composites include their reinforced strength, bonding ability, and rapid and simple application.[11,32,71,72] However, a significant drawback is their tendency to microleakage and poor dimensional stability.[10,32]

Glass ionomer, also known as silver-containing reinforced glass ionomer, has a low coefficient of thermal expansion, fluoride release, and demonstrates chemical and to some extent mechanical attachment to tooth structure. However, its brittleness and lack of resilience are clear downsides.[11,32,71,73]

Modified glass ionomer restorative materials offer the benefits of being simple to apply, hardening when required, and preventing early moisture contact; nevertheless, the resin has the drawbacks of being weaker than composite resin and lacking resilience in case of loading.[74,75]

The core material must be simple to apply, quick to cure, highly resistant, dimensionally stable, have little microleakage, and be applied with a strong bonding mechanism.[11,32,71,75]

AMALGAM CORES: It is a core building component that is simple to use, has strong mechanical characteristics, and works well with posts, pins, and other retentive parts.[76] When there is adequate tooth tissue left, amalgam core performs better.[77] Amalgam's thermal expansion coefficient, limited corrosion resistance, slow setting time, and unfavorable visual characteristics are only a few of its disadvantages. Additionally, resin-based cement-bonded aesthetic crowns cannot be effectively bonded with amalgam cores.[65]

GLASS IONOMER CORES: Because of their low coefficient of thermal expansion, which is comparable to that of tooth structure, chemical bonds to enamel and dentin, and the release of fluoride ions, glass ionomer cements are recommended as core materials. Despite these benefits, glass ionomer cements with or without silver are not appropriate for use as core materials because they lack the necessary tensile strength and fracture resistance.[65]

RESIN CORES: They are favoured in the clinic because to their simplicity of use, attractiveness, and ability to regulate polymerization, among other factors. Dentin adhesives and composite resins can be combined.[65]

When used in combination, they offer the tooth structure a strong bond that increases retention. Due to their mechanical qualities and benefits in chemical bonding, they can be used successfully in teeth that have seen a lot of material loss. Some products' hardness is enhanced up to the dentin hardness ratio depending on the kind and quantity of fillers, making further preparation easier. Its elasticity modules are on level with or higher than those of dentin, and these characteristics provide the material increased resistance. When used with all-ceramic restorations on anterior teeth, it also provides cosmetic benefits. Border compatibility is a significant issue with contemporary composite materials. The restoration's marginal alignment is negatively affected by polymerization shrinkage, and a space is created between the cavity walls and the resin. Negative consequences include marginal discolouration, fracture, and secondary caries might result from fluids, germs, and ions seeping from this cavity.[65]

CERAMIC CORES: The usage of high fracture strength ceramics as the core material in anterior teeth has increased during the past ten years. Depending on the kind of ceramic employed, these materials can, in addition to the cosmetic benefit, be chemically linked to the tooth structure following surface treatments. In the lab, a core structure can be created by pressing around a post that has already been prepared, or a post core can be cast in one piece from glass-infiltrated alumina ceramic. Making the hide and core structure separately and cementing them together during placing is an additional alternative.[65]

## Conclusions

Posts are frequently used to support the restoration of the crown part in endodontically treated teeth.

### References


1. Kenneth M Hargreaves LHB. Cohen's Pathways on the Pulp. 11 ed. Rotstein I, editor: Elsevier; 2016.
2. Keyf F. Flexi-Post'un Çekme ve Basma Kesme Kuvvetlerine Karşı Retansiyonunun Diğer İki Prefabrik Post- Core Sistemiyle Karşılaştırılması. ANKARA: Hacettepe Üniv. ; 1990.
3. Saraç ŞY. İki Farklı Kanal Dolgu Patı İle Doldurulmuş Dişlerde Değişik Post Boşluğu Hazırlama Yöntemlerinin Apikal Sızdırmazlığa Etkisinin Spektrofotometrik Yöntem İle İncelenmesi. Ankara: Hacettepe Üniv. ; 1995.
4. Tjan AHL, Abbate, MF. Temperature Rise at Root Surface During Post Space Preparation. J Prosthet Dent. 1993;691:41-45.
5. Akkayan B, Caniklioğlu, M. B. Farklı Post Tiplerinin Kök Kırıklarına Etkileri ve Post Seçim Kriterleri. Hacettepe Dişhekimliği Dergisi. 1997;21:75-84.
6. Morgano SM, Milot P. Clinical Success of Cast-Metal Posts and Cores. J Prosthet Dent. 1993;701:11-16.
7. Yoldaş HO. Aşırı Harabiyet Gösteren Diş Köklerinin Işık İleten Post Sistemiyle Restore Edilmesi, . Ankara: Gazi Üniv; 1998.
8. Federick DR. An application of the dowel and composite resin core technique. J Prosthet Dent. 1974 324:420-424.
9. Tylman SD. Theory and Practise of Crown and Bridge Prosthesis. 2 ed. St. Louis: Mosby Co.; 1947.
10. Reosenstiel SF, Land MF, Fujimoto J. Contemporary Fixed Prosthodontics. 2 ed. St. Louis: Mosby Co.; 1995.
11. Schillingburg HT, Hobo S., Whitsett LD., Jacobi, R., BrackETT SE. Fundamentals of Fixed Prosthodontics. 3 ed. Chicago: Quıntessence Co.; 1997.
12. Alaçam T, Nalbant, L., Alaçam, A. İleri Restorasyon Teknikleri. 1 ed. Ankara Polat Yayınları; 1998.
13. Reosenstiel SF, Land MF., Junkei F. Contemporary Fixed Prosthodontics. St. Louis: Mosby Co.; 1988.
14. Desort KD. The Prosthodontic Use of Endodontically Treated Teeth; Theory and Biomechanics of Post Preparation. J Prosthet Dent. 1983;492:203-206.
15. Cohen BI, Condos S., Musikant, B. L., Deutsch, A. S. Retention Properties of a Splint Shaft Threaded Post Cut at Different Apical Lengths. J Prosthet Dent. 1992;686:894-898.
16. Walton RE, Torabinejad M. Principles and Practise of Endodontics. Philadelphia: W. B. Saunders Co.; 1989.
17. Perel M, Muraff FI. linical Criteria for Posts and Cores. J Prosthet Dent. 1972;284:405-411.
18. Sorensen JA MJ. Intracoronal reinforcement and coronal coverage: a study of endodontically treated teeth. J Prosthet Dent 1984;516:780-784.
19. Mumford JM, Jednynakiewicz NM. Principles of Endodontic. Philadelphia: Quıntessence Co.; 1988.
20. Caputo AA, Standlee, P. J. Biomechanics in Clinical Dentistry. Chicago: Quintessence Publishing Co.; 1987.
21. Cohen S, Burns, C. R. Pathways of The Pulp. St. Louis: Mosby Co; 1991.
22. Lui JL. Composite Resin Reinforcement of Flared Canals Using Light Transmitting Posts: Quintessence Int.; 1994. 313-319 p.
23. Charbengou GT. Principles and Practise of Operative Dentistry. 3 ed. Philadelphia: Lea & Febiger; 1998.
24. Ingle JI, Bakland, L. K. Endodontics. 4 ed. Philadelphia: Lea & Febiger; 1994.
25. Chandra A, Singh SV. A new classification of post and core. Indian Journal Of Restorative Dentistry. 2015;4:56-58.
26. Sabu J, Vanamala, N., & Prasad, B. S. K. "Monoblock Effect" – A Review of the Concept, Types, and Sealability. Asian Journal of Dental Sciences. 2022;54:137-146.
27. Zhou LL, Wang Q. [Meta analysis of the comparison between cast metal posts' and fiber posts' clinical results]. Shanghai Kou Qiang Yi Xue. 2012;216:709-613.
28. Zhou L, Wang Q. Comparison of fracture resistance between cast posts and fiber posts: a meta-analysis of literature. J Endod. 2013;391:11-15.
29. Parlar ÖZ Ö SA, Aydin C. Post systems in prosthetic dentistry. Gaziantep Medical Journal. 2015;211:51-55.
30. Ring ME. Dentistry, An İllustreated History. Newyork: Mosby Co; 1992.
31. Morgano SM. Restoration of Pulpless Teeth Aplication Of Traditional Principals İn Present and Future Contexts. J Prosthet Dent. 1996;754:379-380.
32. Silvers JE, Johnson MF., Fujimoto, J. Contemporary Fixed Prosthodontics. 2 ed. St. Louis: Mosby Co.; 1995.
33. Tjan AHL, Whang SB. Resistance to Root Fracture of Dowel Channels with Various Thickness of Buccal Dentin Walls. J Prosthet Dent. 1985;534:496-500.
34. Carter DR, Donnelly, JC. The Effect of Dowel Lubrication on Retention of Resin Cemented Dowels. J Prosthet Dent. 1994;723:255-8.
35. Hudis SI, Goldstein, GR. Restoration of Endodontically Treated Teeth: A Review of The Literature. J Prosthet Dent. 1986;551:33-38.
36. Kurer HG. Factors Influencing The Retention of Dowels. J Prosthet Dent. 1977;385:515-518.
37. Standlee JP, Caputo, A. A. Endodontic Dowel Retention with Resin Luting Systems. J Dent Res. 1994;70:446-448.
38. Weine FS. Endodontic Therapy. 4 ed. St. Louis: Mosby Co; 1989.
39. Amarnath GS, Swetha MU, Muddugangadhar BC, Sonika R, Garg A, Rao TR. Effect of Post Material and Length on Fracture Resistance of Endodontically Treated Premolars: An In-Vitro Study. J Int Oral Health. 2015;77:22-28.
40. Colman HL. Restoration of Endodontically Treated Teeth. Dent Clin North Am. 1979;234:647-661.
41. Krupp JD, Caputo, AA., Trabert, DC., Standlee, JP. Dowel Retention with Glass- Ionemer Cement. J Prosthet Dent. 1979;412:163-166.
42. Ruemping DR, Lumd, MR., Schirnel, RJ. Retention of Dowels Subjected To Tensile and Torsional Forces. J Prosthet Dent. 1979;412:159-163.
43. Sidoli CE, King, PA., Setchel, DJ. An Invitro Evaluation of a Carbon Fiber Based Post and Core System. J Prosthet Dent. 1997;781:5-9.
44. Mattison GD. Photoelasyic Stress Analysis of Cast-Gold Endodontic Posts. J Prosthet Dent. 1982;484:407-411.
45. Hanson EC, Caputo AA. Cementing mediums and retentive characteristics of dowels. J Prosthet Dent. 1974;325:551-557.

**46.** Standlee J, Caputo, AA., Hanson, EC. Retention of Endodontic Dowels Effects of Cement Dowel Length Diameter and Design. J Prosthet Dent. 1978;394:400-405.

**47.** Snoek PA, Crougers, N. H. J. The Bond Strength of a Resin Cement to a Coated Titanium Post,. J Dent Res. 1997;96:182.

**48.** Mansfield B, Gallburt, R., Aboushala, A. Tensile Bond Strength Comparison for Endodontic Posts and Luting Agents. J Dent Res. 1997;76:69.

**49.** Jacobi R, Schillingburg, H. T. Pins Dowels and Other Retentive Devices in Posterior Teeth. Dent Clin North Amer. 1993;373:367-390.

**50.** Ingle JI, Teel, S., Wands, D. H. Restoration of Endodontically Treated Teeth and Preparation for Overdenture. Philadelphia: Lea & Febiger; 1994.

**51.** Schnell EJ. Effect of Immediate Dowel Space Preparation on The Apical Seal of Endodontically Filled Teeth. J Oral Surg. 1998;453:470-473.

**52.** Trope M, Maltz, DO., Tronstad, L. Resistance to Fractures of Restored Endodontically Treated Teeth. Endodon Dent Traumatol. 1985;13:108-111.

**53.** Juloski J, Radovic I, Goracci C, Vulicevic ZR, Ferrari M. Ferrule effect: a literature review. J Endod. 2012;381:11-19.

**54.** Fontana PE, Bohrer TC, Wandscher VF, Valandro LF, Limberger IF, Kaizer OB. Effect of Ferrule Thickness on Fracture Resistance of Teeth Restored With a Glass Fiber Post or Cast Post. Oper Dent. 2019;446:E299-e308.

**55.** Cagidiaco MC, Radovic I, Simonetti M, Tay F, Ferrari M. Clinical performance of fiber post restorations in endodontically treated teeth: 2-year results. Int J Prosthodont. 2007;203:293-298.

**56.** Signore A, Kaitsas V, Ravera G, Angiero F, Benedicenti S. Clinical evaluation of an oval-shaped prefabricated glass fiber post in endodontically treated premolars presenting an oval root canal cross-section: a retrospective cohort study. Int J Prosthodont. 2011;243:255-263.

**57.** Ferrari M, Cagidiaco MC, Grandini S, De Sanctis M, Goracci C. Post placement affects survival of endodontically treated premolars. J Dent Res. 2007;868:729-734.

**58.** Ferrari M, Vichi A, Fadda GM, Cagidiaco MC, Tay FR, Breschi L, et al. A randomized controlled trial of endodontically treated and restored premolars. J Dent Res. 2012;917 Suppl:72s-78s.

**59.** AlSaleh E, Dutta A, Dummer PMH, Farnell DJJ, Vianna ME. Influence of remaining axial walls on of root filled teeth restored with a single crown and adhesively bonded fibre post: A systematic review and meta-analysis. J Dent. 2021;114:103813.

**60.** Guzy GE, Nicholls, JI. In vitro Comparison of Intact Endodontically Treated Teeth With and Without Endo-Post Reinforcement. J Prosthet Dent 1979;421:39-44.

**61.** Huang TJG, Schilder, H., Nathanson, D. Effect of Moisture Content and Endodontic Treatment on Some Mechanical Properties of Human Dentin. J Endod. 1992;185:209-215.

**62.** Sheets C. Dowels and Core Foundations. J Prosthet Dent. 1970;231:58-67.

**63.** Kantor ME, Pines, M. S. A Comperative Study of Restorative Techniques for Pulpless Teeth. J Prosthet Dent. 1977;384:405-412.

**64.** Trabert KC, Caputo, A. A., ABOU-RASS, M. Tooth Fracture; A Comparison of Endodontic and Restorative Treatments. J Endod. 1978;411:341-345.

**65.** Karaçolak G. TLŞ. Geçmişten Günümüze Postlar, Yapiştirici Simanlar Ve Kor Materyalleri. Atatürk Üniversitesi Diş Hekimliği Fakültesi Dergisi. 2016;253:0.

**66.** Trabert KC, Cooney JP. The endodontically treated tooth. Restorative concepts and techniques. Dent Clin North Am. 1984;284:923-951.

**67.** Grayson WM. Dental Amalgam; Structure and Properties, In: Anusavice. 10 ed. ed. KJ, editor. Philadelphia1996. 361-365 p.

**68.** Mahler DB, Engle JH, Simms LE, Terkla LG. One-year clinical evaluation of bonded amalgam restorations. J Am Dent Assoc. 1996;1273:345-349, quiz 91.

**69.** Donald HL, Jeansonne BG, Gardiner DM, Sarkar NK. Influence of dentinal adhesives and a prefabricated post on fracture resistance of silver amalgam cores. J Prosthet Dent. 1997;771:17-22.

**70.** Belcher MA, Stewart GP. Two-year clinical evaluation of an amalgam adhesive. J Am Dent Assoc. 1997;1283:309-314.

**71.** Cohen BI, Pagnillo MK, Condos S, Deutsch AS. Four different core materials measured for fracture strength in combination with five different designs of endodontic posts. J Prosthet Dent. 1996;765:487-495.

**72.** Kovarik RE, Breeding LC, Caughman WF. Fatigue life of three core materials under simulated chewing conditions. J Prosthet Dent. 1992;684:584-590.

**73.** Ziebert AJ, Dhuru VB. The fracture toughness of various core materials. J Prosthodont. 1995;41:33-37.

**74.** Christensen GJ. Compomers vs. resin-reinforced glass ionomers. J Am Dent Assoc. 1997;1284:479-480.

**75.** Gladys S, Van Meerbeek B, Braem M, Lambrechts P, Vanherle G. Comparative physico-mechanical characterization of new hybrid restorative materials with conventional glass-ionomer and resin composite restorative materials. J Dent Res. 1997;764:883-894.

**76.** Kane JJ, Burgess JO, Summitt JB. Fracture resistance of amalgam coronal-radicular restorations. J Prosthet Dent. 1990;636:607-613.

**77.** Yanıkoğlu PN. BD. Post-Kor Yapiminda Kullanilan Restoratif Materyaller Ve Özellikleri. Ata Diş Hek Fak Derg. 2004;3.

Cumhuriyet Dental Journal, 26(1): 97-100, 2023
DOI: https://doi.org/10.7126/cumudj. 1213031

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 | Available online, ISSN: 1302-5805 e-ISSN: 2146-2852 | Publisher: Sivas Cumhuriyet Üniversitesi

# *Vital Teeth Bleaching Treatments with In-Office Bleaching: The Case Reports**

***Gürkan Gür[1-a], Gürçağ Gür[2-a], Sevkan Özkan[1-a], Çağatay Çakar[1-a]***

[1] *Department of Restorative Dentistry, Ankara Universty, Faculty of Dentistry, Ankara, Türkiye.*

[2] *Department of Restorative Dentistry, Ankara Universty Graduate School of Health Sciences, Ankara, Türkiye.*

**Corresponding author*

**Case Report**

** This study has presented at the 25th Congress of Balkan Stomatological Society, 19-22 May 2022, Sarajevo-Bosnia and Herzegovina.*

*History*

*Received: 01/12/2022*
*Accepted: 28/01/2023*



**ABSTRACT**

Dental bleaching is one of the preferred treatments by patients to improve facial attractiveness. It is a relatively simple and conservative technique that makes possible to change dental colour by removing discolorations. Four different patients applied to Ankara Universty Faculty of Dentistry for whitening treatment at different times. In clinical examinations, we detected extrinsic discoloration of the teeth. For this reason, we decided to apply office bleaching treatment (Opalescence BOOST, Ultradent Products INC., USA). First of all, measures ( gums were covered with gingival barrier (OpalDam Green, Ultradent Products INC., USA), isolation was provided with cotton pellets ) were taken to protect the lips, gums and oral mucosa. 40% hydrogen peroxide was applied to the maxillary and mandibular teeth inculuding between the second premolars. After 20 minutes of application, hydrogen peroxide was carefully removed with water and cotton pellets have been replaced. After that, a second 20 minutes application was made with the whitening agent. When the application period was over, it was removed with water and the gingival barrier has been removed. Patients were advised to stay away from products containing coloring dark colors such as cigarettes, tea, coffee, chocolate, red wine, cherries, tomato paste for two weeks. At the controls two weeks later, it was seen that the aesthetic expectation of the patients was met.

***Keywords:*** Hydrogen Peroxide, In-office Bleaching, Tooth Discoloration, Vital Bleaching.

a ggur@dentistry.ankara.edu.tr https://orcid.org/0000-0002-5592-0459 b gurcaggur@gmail.com https://orcid.org/0000-0003-2111-1554
c sevkanozkan94@gmail.com https://orcid.org/0000-0002-5831-6847 d discagataycakar@gmail.com https://orcid.org/0000-0001-9923-2132

*How to Cite:* Gür G, Gür G, Özkan S, Çakar Ç. (2023) Vital Teeth Bleaching Treatments with In-Office Bleaching: The Case Reports, Cumhuriyet Dental Journal, 26(1):97-100.

## Introduction

Nowadays, concerns about tooth discoloration have increased[1-3] as more emphasis is being placed on having a ''beautiful smile'' as an expression of health and vitality, mainly by media and dental manufacturers of tooth-whitening products.[4,5] This has increased the popularity of and demand for dental bleaching.[2,3,6] Tooth bleaching is the most frequently requested procedure by patients because it is a highly effective and conservative way to improve the appearance of a patient's smile when compared to invasive restorative treatments.[2] Additionally, dental bleaching increases the oral health–related quality of life.[7,8] In-office dental bleaching has been practiced for more than 100 years and has some advantages over at-home bleaching. In-office bleaching allows close dentist control, avoids material ingestion, and is associated with reduced total treatment time, with great potential for achieving some degree of whitening after one clinical appointment, which enhances patient satisfaction and motivation.[9,10]
The aim of this multiple case reports is to demonstrate the in-office bleaching treatment in vital discolored teeth.

### *Bleaching procedure*

After the whitening procedure was explained in detail, a signed informed consent form was obtained from the patients who applied to the Department of Restorative Dental Treatment of the Faculty of Dentistry of Ankara University with a request for whitening treatment. A photo record of the treatment was taken from the patients. The initial tooth color was measured with the VITA color scale. Color determination was performed with spectrophotometer from the anterior teeth to be whitened and recorded in the patient's file. Before the whitening treatment, the teeth were cleaned with pumice. 40% hydrogen peroxide containing whitening gel (Opalescence BOOST, Ultradent Products INC., USA) for whitening treatment was applied to patients in accordance with the instructions of the manufacturer. In order to provide isolation and protect the tissues, lip retractor, cotton pellets, and dental saliva ejector were used in the treatment. Before the vital whitening treatment, a 1-2 m thick, 4-6 mm wide gum protector (OpalDam Green, Ultradent Products INC., USA) was

applied from the enamel-gum border to the gum to protect the gums and polymerized with an LED light source. Then, the whitening gel in the form of two adjacent tubes was mixed and applied to the buccal surfaces of the teeth to be whitened with a thickness of 1 mm. It was left for 20 minutes. At the end of this period, the gel that lost its effectiveness was washed off with air water spray and removed from the teeth surfaces and the teeth surfaces were dried. After the gingival barrier control, the bleaching agent was applied for the second time for 20 minutes. At the end of the period, the gel that lost its effectiveness was removed with air-water spray and the gingival barrier was removed. After the treatment, tooth color was determined again according to the vita color scale.

### *Case 1*

In the clinical examination of 32-year-old female patient who applied to our department due to the dark color of her teeth, it was determined that her periodontal health was good, no caries were found, and she did not have any pain complaints. It was determined that she did not have any hereditary disease in her anamnesis and did not use any systemic medication. The patient's pre-treatment tooth color was A3 according to the vita color scale. The tooth color of the patient who underwent the whitening procedure was recorded as A1 according to the vita color scale after treatment. (Figure 1,2)

Figure1: Photograph of case 1 before the bleaching treatment

Figure 2: Photograph of case 1 after the bleaching treatment

### *Case 2*

In the clinical examination of 27-year-old female patient who applied to our department due to the dark color of her teeth, it was determined that her periodontal health was good, no caries were found, and she did not have any pain complaints. It was determined that she did not have any hereditary disease in her anamnesis and did not use any systemic medication. The patient's pre-treatment tooth color was A3 according to the vita color scale. The tooth color of the patient who underwent the whitening procedure was recorded as A1 according to the vita color scale after treatment. (Figure 3,4 )

Figure 3: Photograph of case 2 before the bleaching treatment

Figure 4: Photograph of case 2 after the bleaching treatment

### *Case 3*

In the clinical examination of 42-year-old female patient who applied to our department due to the dark color of her teeth, it was determined that her periodontal health was good, no caries were found, and she did not have any pain complaints. It was determined that she did not have any hereditary disease in her anamnesis and did not use any systemic medication. The patient's pre-treatment tooth color was A3 according to the vita color scale. The tooth color of the patient who underwent the whitening procedure was recorded as A1 according to the vita color scale after treatment. (Figure 5,6 )

Figure 5: Photograph of case 3 before the bleaching treatment

Figure 6: Photograph of case 3 after the bleaching treatment

### *Case 4*

In the clinical examination of 24-year-old female patient who applied to our department due to the dark color of her teeth, it was determined that her periodontal health was good, no caries were found, and she did not have any pain complaints. It was determined that she did not have any hereditary disease in her anamnesis and did not use any systemic medication. The patient's pre-treatment tooth color was A3 according to the vita color scale. The tooth color of the patient who underwent the whitening procedure was recorded as A1 according to the vita color scale after treatment. (Figure 7,8 )

Figure 7: Photograph of case 4 before the bleaching treatment

Figure 8: Photograph of case 4 after the bleaching

## Discussion

In modern societies, the external appearance of the individual plays an important role in social relations between individuals. As a result, the aesthetic concerns of individuals are increasing day by day. Today, with the development of restorative materials, all kinds of color, shape, position disorders and problems can be easily solved. However, whitening of teeth with color problems by chemical methods is preferred primarily because it is a more conservative procedure.

The agent that is frequently used in the in-office whitening treatment of vital teeth is hydrogen peroxide. Hydrogen peroxide has been scientifically proven to be harmless and it has been reported that there is no harm in the use of concentrations >35%, and it does not pose a toxic or carcinogenic risk to humans.[11] In this study, we used 40% hydrogen peroxide as a bleaching agent.

In order for the bleaching treatment to achieve effective results in a short time, the rate of decomposition of hydrogen peroxide should be increased. Thus, the disintegration of colored molecules by free oxygen radicals is accelerated.[7] For this purpose, various heat and light sources are used in office bleaching applications.[8,10] However, pulpal irritation and tooth sensitivity may occur with the use of light or heat application with whitening agents, so it is recommended to be very careful in heat and light applications.[12,13] Therefore, we did not use any heat light source together with hydrogen peroxide, which we used as a bleaching agent in our study. We did not detect tooth sensitivity in any of our patients after treatment.

In various studies, the average number of in-office visits for whitening has been recommended as 1-6, and the maximum number of bleaching agent applications in one session has been reported as 3.[14,15] In our study, we applied 40% hydrogen peroxide for 20 minutes in 2 sessions in all cases and achieved the desired color at the end of the treatment. Patients were advised to stay away from products containing coloring dark colors such as cigarettes, tea, coffee, chocolate, red wine, cherries, tomato paste for two weeks. At the controls two weeks later, it was seen that the aesthetic expectation of the patients was met.

## Conclusions

In office vital tooth bleaching is an effective treatment modality that can significantly change the appearance of teeth. Patient satisfaction has been demonstrated after use of professionally dispensed bleaching treatment. Based on the clinical results reported with professional vital tooth bleaching, it is a viable, esthetic treatment for the discolored dentition its conservative nature and little, if any, risk makes it an important part of an esthetic dentistry treatment plan.

## References


1. Shulman JD, Maupome G, Clark DC, & Levy SM (2004) Perceptions of desirable tooth color among parents, dentists and children Journal of the American Dental Association 135(5) 595-604.
2. Joiner A (2004) Tooth colour: A review of the literatüre Journal of Dentistry (Supplement 32) 3-12.
3. Tin-Oo MM, Saddki N, & Hassan N (2011) Factors influencing patient satisfaction with dental appearance and treatments they desire to improve aesthetics BioMed Center Oral Health 23(11) 6.
4. Mehta D, Venkata S, Naganath M, LingaReddy U, Ishihata H, & Finger WJ (2013) Clinical trial of tooth desensitization prior to in-office bleaching European Journal of Oral Science 121(5) 477-481.
5. Pale´ M, Mayoral JR, Llopis J, Valle`s M, Basilio J, & Roig M (2014) Evaluation of the effectiveness of an in-office bleaching system and the effect of potassium nitrate as a desensitizing agent Odontology 102(2) 203-210.
6. Samorodnitzky-Naveh GR, Geiger SB, & Levin L (2007) Patients' satisfaction with dental esthetics Journal of the American Dental Association 138(6) 805-808.
7. McGrath C, Wong AH, Lo EC, & Cheung CS (2005) The sensitivity and responsiveness of an oral health related quality of life measure to tooth whitening Journal of Dentistry 33(8) 697-702.

8. Meireles SS, Goettems ML, Dantas RV, Bona AD, Santos IS, & Demarco FF (2014) Changes in oral health related quality of life after dental bleaching in a double-blind randomized clinical trial Journal of Dentistry 42(2) 114-121.
9. Tay LY, Kose C, Loguercio AD, & Reis A (2009) Assessing the effect of a desensitizing agent used before in-office tooth bleaching Journal of the American Dental Association 140(10) 1245-1251.
10. He LB, Shao MY, Tan K, Xu X, & Li JY (2012) The effects of light on bleaching and tooth sensitivity during in-office vital bleaching: A systematic review and meta-analysis Journal of Dentistry 40(8) 644-653.
11. Weitzman SA, Weitberg AB, Stossel TP, Schwartz J, Shklar G. Effects of hydrogen peroxide on oral carcinogenesis in hamsters. J Periodontol 1986;57:685-688.
12. Buchalla W, Attin T. External bleaching therapy with activation by heat, light or laser—a systematic review. Dent Mater 2007; 23: 58696.
13. Baik JW, Rueggeberg FA, Liewehr FR. Effect of lightenhanced bleaching on in vitro surface and intra pulpal temperature rise. J Esthet Restor Dent 2001; 13: 370-378.
14. Auschill TM, Hellwig E, Schmidale S, Sculean A, Arweiler NB. Efficacy, side-effects and patients' acceptance of different bleaching techniques (OTC, in-office, at-home). Oper Dent 2005; 30: 156-163.
15. Matis BA, Cochran MA, Wang G, Eckert GJ. A clinical evaluation of two in-office bleaching regimens with and without tray bleaching. Oper Dent 2009; 34: 142-149.

Cumhuriyet Dental Journal, 26(1): 101-104, 2023
DOI: https://doi.org/10.7126/cumudj. 1213192

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 | Available online, ISSN: 1302-5805 e-ISSN: 2146-2852 | Publisher: Sivas Cumhuriyet Üniversitesi

# *Non-Vital Discolared Teeth Bleaching Using the Walking Bleach Technique: A Case Report**

***Gürçağ Gür*[1-a]**

[1] *Department of Restorative Dentistry, Ankara Universty Graduate School of Health Sciences, Ankara, Türkiye.*
**Corresponding author*

**Case Report**

* *This study has presented at the 25th Congress of Balkan Stomatological Society, 19-22 May 2022, Sarajevo-Bosnia and Herzegovina.*

*History*

*Received: 01/12/2022*
*Accepted: 28/01/2023*



**ABSTRACT**

Recently a visually pleasing smile has become a major concern for the patients; therefore, dental bleaching has gained importance due to its safety and great aesthetic results. A female patient presented with intrinsic discolorated maxillary central incisors after endodontic therapy. Maxillary central incisors were isolated with rubber dam and 2mm of the gutta-percha was removed in an apical direction beyond the cemento-enamel junction. Glass ionomer cement was used as a barrier material. Mixture of hydrogen peroxide and sodium perborate placed in the pulp chamber and the teeth were temporarily restored with zinc phosphate cement. Following the treatment, a satisfactory aesthetic result was achieved. In this case, using the walking bleach technique was found to be successful in whitening discolored teeth after endodontic therapy. This method can be recommended as a safe alternative for treating the discolored devitalized teeth.

***Keywords:*** Hydrogen Peroxide, Sodium Perborate, Tooth Discoloration, Walking Bleach Technique.

a gurcaggur@gmail.com https://orcid.org/0000-0003-2111-1554 b

*How to Cite:* Gür G. (2023) Non-Vital Discolared Teeth Bleaching Using the Walking Bleach Technique: A Case Report, Cumhuriyet Dental Journal, 26(1):101-104.

## Introduction

It is known that discoloration occurs quite frequently in devital, endodontically treated teeth, usually resulting from pulpal injuries, contamination of the pulp cavity, pulp tissue remnants, and root filling materials.[1,2] Iron released from substances induced by the degradation of blood during hemolysis of erythrocytes can be converted to ferric sulfide (a black compound), may result in dark staining of the tooth.[3]

Many patients find the change in color disturbing and unaesthetic, especially when their anterior teeth are affected. In these cases, dental treatment commonly used by physicians is internal bleaching, also known as intracoronal or walking bleaching technique. Compared to alternative treatments such as veneers or crowns, this bleaching procedure is minimally invasive, with a relatively low cost.[4]

However, this technique has some limitations if the darkening is severe and has lasted for a long time. Concerns about its adverse effects due to possible recurrence of darkened color have also been reported.[5] Moreover, another very rare side effect is external cervical root resorption.[6]

Common bleaching agents used to whiten devital teeth include hydrogen peroxide, carbamide peroxide, and sodium perborate.[2] Among the non-vital teeth whitening techniques available, the walking bleach is an option which consists of a combination of whitening agents such as sodium perborate (powder) and 30% hydrogen peroxide (liquid); which are added to the pulp chamber and exchanged every 3 to 7 days. The process is continued until the desired whiteness is obtained.[2,7]

Currently, the most common devital whitening method is the walking bleaching technique. In this technique, mostly sodium perborate paste is mixed with hydrogen peroxide or water and placed in the pulp chamber. After that, the tooth is temporarily restored and the process is repeated at intervals of 3 to 7 days until the wanted result is obtained.[4,8,9] The application is simple, fast and effective as well as clinically reliable can be listed among the reasons for the frequent use of this technique.[9]

The purpose of this case report is to present the walking bleach technique in non-vital endodontically treated teeth.

## Case Report

A 45-year-old female patient was admitted to Ankara University Faculty of Dentistry, Department of Restorative Dentistry with the complaint of discoloration in the two maxillary central teeth. As a result of clinical and radiological examinations, it was observed that the teeth were root canal treated and there were widespread discolorations on the buccal and palatal surfaces of the crowns. In order to remove the discoloration, it was decided to apply bleaching with the "walking bleaching" technique. To begin the bleaching treatment, an initial radiograph was taken to assess the conditions of the endodontic treatment and periodontal tissues. There was no periapical lesion, endodontic treatment was satisfactory. Initial photographs of the teeth were taken to compare the degree of discoloration of the related teeth before whitening with those after the treatment (Figure 1). After isolating the teeth with a rubber dam, suitable access cavities were prepared and the root canal fillings were removed with a steel round bur 2 mm below the enamel cement composition (Figure 2). In order to remove the smear layer formed during this procedure, the cavity was washed with 5.25% sodium hypochlorite solution followed by 17% EDTA solution and dried. To prevent leakage in the coronary region, 2 mm thick glass ionomer cement (Fuji IX, GC Corporation, Tokyo, Japan) was placed in the canal openings (Figure 3). Before applying the devital bleaching agent to the pulp chambers, 37% orthophosphoric acid was applied to the enamel tissue in the cavity. Sodium perborate tetrahydrate (TEKKİM Kimya Sanayi, Bursa, Türkiye) and 30% hydrogen peroxide (TEKKİM Kimya Sanayi, Bursa, Türkiye) mixture was formed (1gm powder with 0.5ml liquid) and it was placed in the pulp chamber and condensed with a wet cotton pellet. Dry cotton was tightly placed over this the access cavity was sealed with zinc phosphate cement (Figure 4). The patient was recalled after 1 week for assessment.

At one week visit, both #11 and #21 showed definite improvement in appearance except near the middle third of the tooth which still showed discoloration. Hence, the bleaching procedure was repeated and the patient was recalled again after 1 week to assess the bleaching results. At two-week visit, the discoloration was completely removed and shade of the patient was enhanced. After the bleaching agent was removed from the pulp chamber by washing with distilled water, calcium hydroxide (Ca(OH)2) paste (Calcicure, Voco, Germany) was applied to the cavities to neutralize the effectiveness of carbamide peroxide, and sterile cotton pellets were placed on them and the cavities were temporarily restored with cement. After the removal of Ca(OH)2 remaining in the cavity in the fourth session, held one week later, the teeth were permanently restored with light-cured composite resin material (Clearfil Majesty Esthetic, Kuraray, Germany) (Figure 5). In the control performed three months later, it was observed that the patient did not have any discomfort and the colors of the teeth remained stable. In addition, no pathology was found in the radiological examination.

Figure 1: Photo before whitening treatment

Figure 2: Prepared cavity

Figure 3: 2 mm thick glass ionomer cement

Figure 4: Zinc phosphate cement

Figure 5. Photo after whitening treatment

## Discussion

Though the mechanism of bleaching is not clear, it is based on oxidation. Whitening agents used in dentistry usually consist of various forms of hydrogen peroxide, such as hydrogen peroxide, sodium perborate, carbamide peroxide.[8,10,11] Preparations containing carbamide peroxide are known to have the same oxidizing power as hydrogen peroxide and sodium perborate.[10] When carbamide peroxide comes into contact with tissue, depending on the concentration of urea, ammonia, carbon dioxide, hydrogen peroxide, and the formulation, different levels of oxygen are released.[9,10,11] In the thermocatalytic method, the released bases used in combination with hydrogen peroxide, one of several whitening methods, cause a pH drop in the cervical region of the tooth and ultimately lead to cervical root resorption.[9,12]

Therefore, nowadays, the thermocatalytic method is not preferred for devital teeth whitening, and the walking whitening technique is often used.[13] In our study, we preferred the walking bleaching technique instead of the thermocatalytic technique to avoid possible cervical root resorption.

Hansen-Bayless and Davis[14] reported that to avoid bleaching agents from reaching the apical region root canal filling alone is not sufficient. Various researchers have recommended the use of a cervical insert over the canal filling to prevent apical and lateral penetration of bleaching agents and external root resorption.[15,16] Thus, in our case, the canal fillings were covered with glass ionomer cement to prevent the risk of cervical resorption.

Spasser first described the bleaching technique in which a paste of sodium perborate and water is placed into the access cavity.[17] Nutting and Poe[18] modified this technique when they replaced the water with hydrogen peroxide in 1963 and reported that sodium perborate was more effective in mixing with hydrogen peroxide instead of distilled water. In our study, we used a mixture of sodium perborate powder and 30% hydrogen peroxide as a bleaching agent.

Holmstrup et al.[19] reported that a ratio of 2:1 (g/ml) bleach mixture of sodium perborate and hydrogen peroxide is most suitable mix for non-vital teeth bleaching. In this case, we also used a mixture of 0.5 ml of hydrogen peroxide and 1 g of sodium perborate powder.

Nutting EB et al.[20] reported that for successful whitening occurs after 2 to 4 sessions, devital whitening agent should be changed every 3 to 7 days depending on the severity of the discoloration. In our case, the whitening agent was changed every 7 days and the desired color change was observed at the end of 3 sessions.

Following the treatment, the teeth must be restored with composite resins that have a good enough adhesion to enamel and dentin to prevent re-infection of the teeth by microorganisms, for the re-infiltration of dyes into the tooth and for the durability of the tooth to be improved.[21,22] Studies have shown that peroxide or oxygen remaining in the cavity after bleaching, inhibits polymerization of composite resins. In addition, the adhesion of composite resins can negatively be effected by the changes in enamel structure resulting from bleaching.[23] Therefore, to buffer the acidic pH and prevent possible resorption of the cervical root, a calcium hydroxide paste placed in the pulp chamber should be applied within a week after bleaching.[21] Studies have shown that calcium hydroxide applied to the pulp chamber does not affect the bonding in permanent restorations.[24]

## Conclusions

In this case report, it has been shown that the walking bleach technique, which is used as an alternative to traditional invasive methods such as metal supported or full ceramic crowns, composite or porcelain laminates, can be successfully applied in the discoloration of devital teeth. This method can be recommended as a safe alternative for treating with discolored devitalized teeth.

## References


1. Zimmerli B, Jeger F, Lussi A. Bleaching of nonvital teeth. A clinically relevant literature review. Schweiz Monatsschr Zahnmed 2010;120:306–320.
2. Attin T, Paque F, Ajam F, et al. Review of the current status of tooth whitening with the walking bleach technique. Int Endod J 2003;36:313–329.
3. Rotstein I, Zalkind M, Mor C, et al. In vitro efficacy of sodium perborate preparations used for intracoronal bleaching of discolored non-vital teeth. Endod Dent Traumatol 1991;7:177–180.
4. Spasser HF. A simple bleaching technique using sodium perborate. N Y State Dent J 1961:332–334.
5. Brown G. Factors influencing successful bleaching of the discolored root-filled tooth. Oral Surg Oral Med Oral Pathol. 1965;20:238-244.
6. Bersezio C, Sánchez F, Estay J, et al. Inflammatory markers IL-1β and RANK-L assessment after non-vital bleaching: a 3-month follow-up. J Esthet Restor Dent. 2020;32:119-126.
7. Serene TP, Snyder DE. Bleaching technique. (Pulpless anterior teeth). J South Calif Dent Assoc. 1973;1:30-32.
8. MacIsaac AM, Hoen C. Intracoronal bleaching: concerns and considerations. J Can Dent Assoc 1994;60:57-64.
9. Friedman S, Rotstein I, Libfeld H, Stabholz A, Heling I. Incidence of external root resorption and esthetic results in 58 bleached pulpless teeth. Dent Traumatol 1988;4:23-26.
10. Haywood VB. History, safety, and effectiveness of current bleaching techniques and applications of the nightguard vital bleaching technique. Quintessence Int 1992;23: 1
11. Perrine G, Reichl R, Baisden M, Hondrum S. Comparison of 10% carbamide peroxide and sodium perborate for intracoronal bleaching. General Dent 1999;48:264-270.
12. Gimlin DR, Schindler WG. The management of postbleaching cervical resorption. J Endod 1990;16:292-297.
13. Madison S, Walton R. Cervical root resorption following bleaching of endodontically treated teeth. J Endod 1990;16:570-574.
14. Hansen-Bayless J, Davis R. Sealing ability of two intermediate restorative materials in bleached teeth. Am J Dent 1992;5:151-154.
15. Zarenejad N, Asgary S, Ramazani N, et al. Coronal microleakage of three different dental biomaterials as intra-orifice barrier during nonvital bleaching. Dent Res J (Isfahan) 2015;12(6):581–588.

**16.** Sharma DS, Sharma S, Natu SM, et al. An in vitro evaluation of radicular penetration of hydrogen peroxide from bleaching agents during intra-coronal tooth bleaching with an insight of biologic response. J Clin Pediatr Dent 2011;35(3):289–294

**17.** Spasser HF. A simple bleaching technique using sodium perborate. NYS Dent J. 1961; 27(8-9):332-334.

**18.** Nutting EB, Poe GS. A new combination for bleaching teeth. J So Calif Dent Assoc 1963; 31(9): 289-291.

**19.** Holmstrup G, Palm AM, Lambjerg-Hansen H. Bleaching of discoloured root-filled teeth. Endod Dent Traumatol 1988;4:197–201.

**20.** Nutting EB, Poe GS. A new combination for bleaching teeth. J South Californian Dent Assoc 1963;31:289.

**21.** Baratieri LN, Ritter AV, Monteiro Jr S, Caldeira de Andrada MA, Cardoso Vieira LC. Nonvital tooth bleaching: Guidelines for the clinician. Quintessence Int 1995;26:1.

**22.** Abou-Rass M. Long-term prognosis of intentional endodontics and internal bleaching of tetracycline-stained teeth. Compend Contin Educ Dent 1998;19:1.

**23.** Torneck C, Titley K, Smith D, Adibfar A. The influence of time of hydrogen peroxide exposure on the adhesion of composite resin to bleached bovine enamel. J Endod 1990;16:123-128.

**24.** Kehoe JC. pH reversal following in vitro bleaching of pulpless teeth. J Endod 1987;13:6-9.

Cumhuriyet Dental Journal, 26(1): 105-111, 2023
DOI: https://doi.org/10.7126/cumudj. 1213205

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 | Available online, ISSN: 1302-5805 e-ISSN: 2146-2852 | Publisher: Sivas Cumhuriyet Üniversitesi

# *Early Treatment of a Class III Patient with Chincup: A Case Report**

***Gözde Gür*[1-a*]*, Dilek Erdem*[2-b]**

[1] *Department of Orthodontics, Graduate School of Health Sciences, Ankara University, Ankara, Türkiye.*
[2] *Prof. Dr. Department of Orthodontics, Faculty of Dentistry, Ankara University, Ankara, Türkiye.*
**Corresponding author*

**Case Report**

** This study has presented at the 25th Congress of Balkan Stomatological Society, 19-22 May 2022, Sarajevo-Bosnia and Herzegovina.*

*History*

*Received: 01/12/2022*
*Accepted: 08/02/2023*



**ABSTRACT**

Class III malocclusions are usually related to growth and mandibular posture. The mixed dentition stage of development may provide a useful opportunity to embark upon orthodontic therapy to correct a Class III malocclusion. Chin cap is a useful appliance in growingpatients that exhibit mandibular prognathis. This case report aim to describe an early treatment of a Class III malocclusion by using a chincup. This case report presents a 9 year-old girl with a functional Class III malocclusion and anterior crossbite. She has treated by using chincup for 10 months. The occlusion was elevated with a maxillary appliance, and the maxilla was freed from the restriction of the mandible. In this way, the maxilla was able to continue its development and the growth of the mandible was limited by chincup. Anterior cross-bite was corrected and a positive overjet were achieved. Facial profile was improved. While posterior rotation of the mandible was expected with the effect of the chincup, SN-GoGn angle didn't change in this case. At the end of treatment, a class I relationship and a smooth soft tissue profile were obtained.

***Keywords:*** Chincup, Class III Malocclusion, Early Orthodontic Treatment, Anterior Crossbite Treatment.

a gozdemgur@gmail.com https://orcid.org/0000-0002-4133-5355 b dilekerdem-06@hotmail.com https://orcid.org/0000-0002-4694-8679

*How to Cite:* Gür G, Erdem D. (2023) Early Treatment of a Class III Patient with Chincup: A Case Report, Cumhuriyet Dental Journal, 26(1):105-111.

## Introduction

Class III malocclusions can be associated with the mandibular posture and growth pattern of the individual. Various skeletal and dental compensation components play a role in the etiology of Class III malocclusion.[1] Malocclusion formation may manifest as maxillary retrognathism, mandibular prognathism, protrusive maxillary dentition, retrusive mandibular dentition, and a combination of these.[2] Class III malocclusion can be clinically divided into two groups: (a) "false or functional Class III"; mandibular closure interferes early with the muscle reflex, resulting in Class IIIand (b) "true Class III"; skeletally Class III is observed.[3]

Forward displacement of the mandible due to early contact causes anterior crossbite, which is a common clinical feature of false Class III and skeletal Class III malocclusions.[4,5] Skeletal and dent-alveolar components differentiate between true Class III and false Class III malocclusion. Patients with true Class III malocclusion show a skeletal Class III pattern characterized by an undersized maxilla, protruding mandible, or a combination of these two conditions. In patients with pseudo-Class III malocclusion, skeletal Class I malocclusion accompanying normal maxilla and mandible dimensions is observed.[6]

In general, the profile of patients with Class III malocclusion is concave and the nasomaxillary area is retrusive. In these patients, protrusion of the lower lip is evident. The mandibular arch is wider than the maxillary arch, and negative overjet and reduced overbite are among the clinical findings.[7,8]

Orthodontists should consider the growth and developmental period of the patient and the skeletal factors that cause the anomaly when treating a patient with Class III anomaly. Between growth periods the mixed dentition stage is among the most appropriate periods to initiate the necessary treatment to correct a Class III malocclusion. Class III malocclusions that are thought to respond to functional therapy should be treated when growth is active. The chin cap is the first-choice appliance in the treatment of patients with active growth development characterized by mandibular prognathia. Chincup allows us to achieve orthopedic effect as in the treatment with Class III activator and face mask.[9]

This case report aims to describe the early treatment of a Class III malocclusion using a chincup.

## Case Report

### *Case History*

A 9-year-old female patient was admitted to the Department of Orthodontics, Faculty of Dentistry, Ankara University, with a complaint of anterior mandible by her family. The patient, who did not have a similar anomaly in her family history, did not have bad habits such as thumb

sucking, lip biting, and using a long-term bottle. The patient was breathing through her nose and there was no respiratory problem. Her medical history was clear and she had no signs or symptoms of temporomandibular joint dysfunction. The patient's puberty symptoms were negative and the patient was in the prepubertal period. (Figure 1)

According to clinical examination, dental Class III molar relationship was present. There was 1 mm left deviation in the lower midline. The patient has a straight profile. The freeway area was 4 mm. The DeNevreze maneuver was positive and the patient was able to move the lower jaw head-on without external intervention.[10] (Figure 2)

According to the model analysis; There were -2 mm overjet, 2 mm overbite, and anterior crossbite (Figure 3). According to Moyers analysis[11]; Maxillary arch length deviation was 0 mm and Mandibular arch length deviation was 1.5 mm. (Figure 4)

According to the cephalometric analysis[12], she had a Class I skeletal structure (ANB= 0˚). There was a normodivergent growth pattern (GoGn/SN= 30˚). According to Steiner soft tissue analysis[13], the upper lip was 1 mm retrusive and the lower lip was 2.5 mm protrusive. (Table 1).

According to the hand and wrist radiographs of the female patient with MP3= skeletal stage, it was observed that 86.2% of the skeletal development was completed (Figure 5).

According to the panoramic radiograph taken, our patient was in the early mixed dentition period. There were no missing teeth. (Figure 6)

Positive DeNevreze maneuver[10] and skeletal Class I pattern showed us that this patient was in the Pseudo Class III group.[3]

Treatment goals for this patient were to free the maxilla from confinement of the mandible, to create an ideal Angle class I molar relationship, and an ideal overjet and overbite.

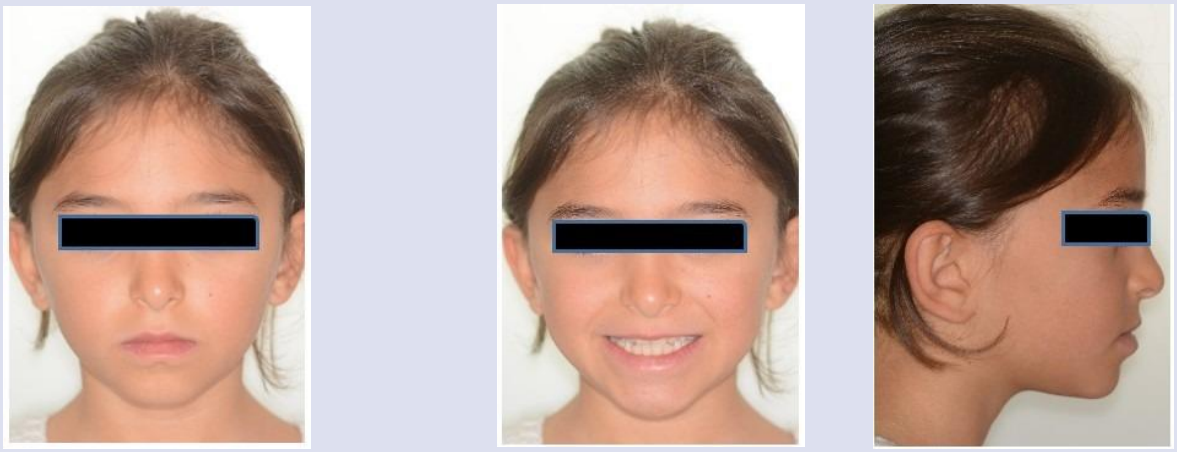


Figure 1. (a) Pretreatment photographs (b) Frontal view (c) Lateral view

Figure 2. Pretreatment intraoral photographs

Figure 3. Pretreatment overjet and overbite photographs.

Figure 4. Pretreatment occlusal photographs.

Figure 5. Pretreatment hand and wrist radiograph.

Figure 6. Pretreatment panoramic radiograph.

### *Treatment Progress*

A tight fit maxillary movable appliance is fabricated with a vestibule arc and 2 clasps on the upper first permanent molars. The posterior occlusion of the appliance was raised (Figure 7). The patient was told to wear the maxillary appliance all day, except for eating, contact sports and brushing teeth. She used the chincup, which consists of a head-supported headgear and a chinrest placed on the chin, for 12-15 hours per day to prevent the extreme development of the lower jaw. A force of 250 g was applied to each side (Figure 8). The patient was examined and progress of the treatment was observed monthly by an orthodontist.

Figure 7. Maxillary removable appliance.

Figure 8. Chincup.

## Results

Pre and post-treatment lateral cephalograms and photographs were taken on the same machine by the same person.

A positive overjet and overbite were obtained after 10 months of the treatment. 1 mm overjet and 2,5 mm overbite were achieved (Figure 9). According to Moyers analysis[14] after treatment; maxillary arch length deviation was 0 mm and Mandibular arch length deviation was 0 mm (Figure 10)

According to the hand and wrist radiographs taken after the treatment, it was observed that the patient was in the S skeletal stage and showed 4,4% skeletal growth during the 10-month treatment period (Figure 11).

Panoramic radiograph taken after the treatment showed that the patient was still in the mixed dentition period and the permanent canines tended to erupt (Figure 12).

According to the post-treatment cephalometric radiograph[12], there was a positive increase of 1,5 degrees in SNA and ANB increased to 1,5 degrees. The SNB had not changed. The patient's Class I skeletal structure (ANB= 1.5˚) and normodivergent growth pattern (GoGn/SN= 30˚) was preserved. According to Steiner soft tissue analysis[13], the upper lip protruded 1,5 mm (Table 1), and accordingly, a positive change was observed in the patient's profile with growth and development (Figure 13).

In the total superimposition of the pre and post-treatment lateral cephalogram made according to the criterias of Björk[15]; forward and downward growth in the nasion, maxilla and mandible. The negative overjet became a positive overjet. Following these, positive changes also were observed in soft tissue. In the local maxillar superimposition of the pre and post-treatment lateral cephalogram made according to the criterias of the Björk[15]; along with parallel descent of the maxilla, sagittal and vertical dentoalveolar development was observed in the molars and incisors. In the local mandibular superimposition; a slight anterior rotation in the mandible, retrusion and dentoalveolar development in incisors, mesialization and dentoalveolar development in molars were observed (Figure 14). This female patient in the prepubertal period will continue to use chincup for control purposes until her growth and development is over.

Figure 9. Post-treatment intraoral photographs, overjet and overbite photographs.

Figure 10. Post-treatment occlusal photographs.

Figure 11. Post-treatment hand and wrist radiograph.

Figure 12. Post-treatment panoramic radiograph.

Figure 13. (a) Post-treatment photographs (b) Frontal view (c) Lateral view

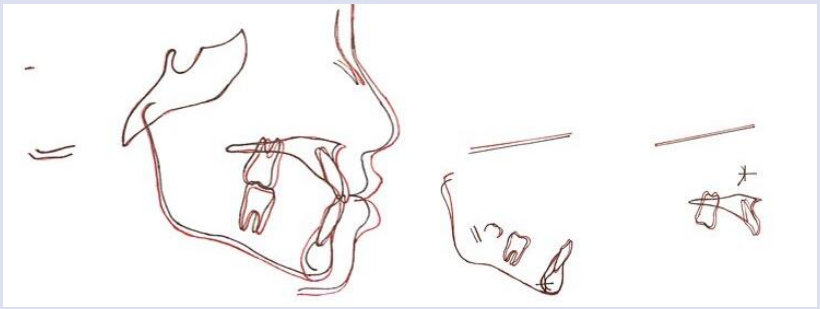


Figure 14. Pre- and post-treatment tracings superimposed

**Table 1.** Pre- and post-treatment cephalometric analysis.

| | Pretreatment | Post-treatment |
|---|---|---|
| SNA (degrees) | 76.5˚ | 78˚ |
| SNB (degrees) | 76.5˚ | 76.5˚ |
| ANB (degrees) | 0˚ | 1.5˚ |
| SND (degrees) | 75˚ | 75˚ |
| 1-NA (length/degrees) | 3 mm / 22˚ | 3 mm/ 25˚ |
| 1-NB (length/degrees) | 4.5 mm / 27.5˚ | 2.5 mm/ 22.5˚ |
| Pg-NB (length) | 0.5 mm | 0.5 mm |
| Holdaway difference (length) | 4 mm | 2 mm |
| Interincisal angle (degrees) | 130.5˚ | 131˚ |
| Occ/SN (degrees) | 18.5˚ | 18.5˚ |
| GoGn/SN (degrees) | 30˚ | 30˚ |
| Steiner Soft Tissue Analysis (length) | UL = -1 mm<br>LL = 2.5 mm | UL = 1.5 mm<br>LL = 4.5 mm |
| IMPA (degrees) | 95˚ | 90.5˚ |

## Discussion

Short-term use of orthopedic appliances is an effective treatment choice in children with Class III malocclusion and growing children.[16] Bionator[17], Frankel (FR-III)[18], chin cup[19], protraction face mask, double-plate appliance[20], Eschler progenic appliance[21] are used for treatment of Class III. In the treatment of functional Class III or skeletal Class III malocclusions, the suitability of these appliances is decided following the examination of the patient's clinical and skeletal measurement values. Treatment of pseudo or functional Class III malocclusion should be initiated as soon as possible before the patient's growth development is over. In the early treatment Class III malocclusion, chincup can be used by the patient to stop the unwanted overgrowth of the mandible.[22]

In this case, pseudo class III accompanying anterior crossbite diagnosed in the prepubertal period were treated with a maxillary appliance and chincup. The posterior of the maxillary appliance is elevated. Thus, it was aimed to free the maxilla from the confinement of the mandible and to ensure that the maxilla grows comfortably with normal growth and development without pressure from the mandible. The purpose of the chincup application for 12-15 hours is to inhibit the unwanted forward growth of the mandible.

At the end of the treatment, the negative overjet turned into a positive overjet. The following positive changes were observed in the soft tissue. With the use of the posteriorly raised maxillary removable appliance, anterior crossbite was eliminated and the maxilla was freed and it could easily continue its own growth development.

Posterior rotation of the mandible is usually observed as a result of treatment with the chincup.[23] However, in this case, contrary to expectations, there was a slight anterior rotation of the mandible. The use of a posteriorly raised maxillary appliance had a posterior bite block effect and with a positive overjet the condyle found its proper place. The condyle was enlarged, the growth angle of the condyle neck changed with the effect of the chincup and a slight anterior rotation of the mandible happened. Mesialization was observed in mandibular molars with the use of leeway space reserve[24], and retrusion was observed in mandibular incisors with the effect of chincup.

## Conclusions

At the end of the treatmentof thie case, Class I dental relationship and smooth soft tissue profile were obtained by using chincup. Raising the posterior bite while using chincup is an effective recommended method while treating pseudo Class III malocclusions in the early growth period patients and is also seen in the treatment outcome of this case.

## References


1. Cevidanes L, Baccetti T, Franchi L, McNamara Jr JA, De Clerck H. Comparison of two protocols for maxillary protraction: bone anchors versus face mask with rapid maxillary expansion. The Angle Orthodontist, 2010;80:799–806.
2. Celikoglu M, Oktay H. Effects of maxillary protraction for early correction of class III malocclusion. European Journal of Orthodontics, 2014;36:86–92.
3. Moyers RE. Handbook of Orthodontics, Year Book Medical Publishers, 1988.
4. Guyer EC, Ellis EE, McNamara Jr JA, Behrents RG. Components of Class III Malocclusion in Juveniles and Adolescents. The Angle Orthodontist, 1986;56:7–30.
5. Borrie F, Beam D. Early correction of anterior crossbites: a systematic review. J Orthod, 2011;38:175–184.
6. Rabie AB, Gu Y. Diagnostic criteria for pseudo-Class III malocclusion. Am J Orthod Dentofacial Orthop, 2000;1171:1–9.
7. Gelgor IE, Karaman AI. Non-surgical treatment of Class III malocclusion in adults: two case reports. J Orthod, 2005;32:89-97.
8. Ngan P, Hagg U, Yiu C, Merwin D, Wei SHY. Soft tissue and dentoskeletal profile changes associated with maxillary expansion and protraction headgear treatment. Am J Orthod Dentofacial Orthop,1996;8-11.
9. Rabie M, Wong RWK, Min GU. Treatment in borderline Class III malocclusion: Orthodontic camouflage (extraction) versus orthognathic surgery. Open Dent J, 2008;109:38-49.
10. Kale B, Buyukcavus MH. Comparison of three-dimensional soft-tissue evaluations between skeletal and pseudo-class III malocclusions. Sci Rep, 2020; 10: 14717.
11. Buwembo W, Lubago S. Moyer's method of mixed dentition analysis: a meta-analysis. Afr Health Sci, 2004; 4(1): 63–66.
12. Hussien E, Al-Khateeb S, Mowais MA. Palestinians Norms Of Steıner Cephalometric Analysis. World Journal of Orthodontics,2010;11(4): 5-9.
13. Holdaway RA. A soft-tissue cephalometric analysis and its use in orthodontic treatment planning. Part I. American Journal of Orthodontics,1983; 84: 1-28.
14. Galvão MB, Dominguez GC, Tormin ST, Akamine A. Applicability of Moyers analysis in mixed dentition: A systematic review. Dental Press Journal of Orthodontics,2013;18(6): 100-105.
15. Dibbets J.M.H. The puzzle of growth rotation. American Journal of Orthodontics, 1985; 87(6): 473-480.
16. Long H, Jian F, Lai W. Weak evidence supports the short-term benefits of orthopaedic treatment for Class III malocclusion in childreN. Evidence-Based Dentistry, 2014;15: 21–22.
17. Levrini A, Levrini L. Il Bionator concetti classici e nuove acquisizioni, Rivista Italiana di Stomatologia, 1993;10:499-506.
18. Proffit WR, Fields Jr HW, Sarver DM. Contemporary Orthodontics, Elsevier Health Sciences, Philadelphia, Pa, USA, 2014.
19. Sugawara J, Asano T, Endo N, Mitani H. Long-term effects of chincap therapy on skeletal profile in mandibular prognathism. Am J Orthod Dentofacial Orthop, 1990;98: 127-133.
20. Gencer D, Kaygisiz E, Yuksel S, Tortop T. Comparison of double-plate appliance/facemask combination and facemask therapy in treating Class III malocclusions. Angle Orthodontist, 2015;85: 278–283.
21. De Almeida MR, De Almeida RR, Oltramari-Navarro PVP, Conti ACDCF, Navarro RDL, Camacho JGDD. Early treatment of Class III malocclusion: 10-year clinical follow-up. Journal of Applied Oral Science, 2011;19: 431– 439.
22. Turley PK. Treatment of the class III malocclusion with maxillary expansion and protraction. Seminars in Orthodontics, 2007;13,143–157.
23. Graber Lee W. Chin cup therapy for mandibular prognathism. Am J Orthod,1977;72,23-41.
24. Gianelly AA. Leeway space and the resolution of crowding in the mixed dentition. Seminars in Orthodontics, 1995;1: 188-194.