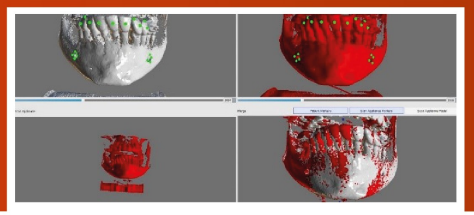
CUMHURIYET DENTAL JOURNAL

The Official Journal of Sivas Cumhuriyet University Faculty of Dentistry



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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.

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INDEXING

CUMHURIYET DENAL JOURNAL

AUTHOR GUIDELINE

Cumhuriyet Dental Journal (CDJ) is the Official Publication of the Cumhuriyet University, Faculty of Dentistry. CDJ accepts original experimental investigations and review articles concerning topics of clinical relevance to the general dental practitioner. Case reports and technique articles will be very critically reviewed in terms of interest to the general dental practitioner and the supporting data provided.

CDJ accepts articles in English. Submitting a paper to CDJ is free of charges. In addition, CDJ has not have article processing charges.

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CDJ is published using an open access publication model, meaning that all interested readers are able to freely access the journal online without the need for a subscription. Manuscripts will be reviewed by the editor, and at least two reviewers with expertise within the scope of the article.In addition, CDJ use double- blind review process (every effort is made to prevent the identities of the authors and reviewers from being known to each other)

Review Process

Double-Blind Peer Review Process

CDJ uses double-blind review, which means that both the reviewer and author identities are concealed from the reviewers, and vice versa, throughout the review process. Within this aim, the authors need to ensure that their manuscripts are prepared in a way that does not give away their identity. Editors will email selected Reviewers the title and abstract of the submission, as well as an invitation to log into the journal web site to complete the review. Reviewers enter the journal web site to agree to do the review, to download submissions, submit their comments, and select a recommendation.

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Manuscript Format and Style

General

Manuscript length depends on manuscript type. Paper dimensions should be 8.5 × 11 inches with 2.5 cm margins on all sides. Please use normal, plain font (12-point Times New Roman), justified and number all pages consecutively. Indent or space paragraphs.

Manuscript Types Accepted

Original Research Article: Title, Abstract, Introduction, Materials and Methods, Results, Discussion, Conclusions, Acknowledgements, References, Tables and Figure Legends

Review Articles: Although a Review article (particularly following a systematic review) may adhere to the format of the Original Research Article, both Review and Focus Articles need not contain Materials and Methods, Results or Discussion sections, and may instead employ other headings as relevant for the topic addressed.

Case Report: Title, Abstract, Introduction, Case Report, Discussion, Conclusions, Acknowledgements, References, Tables and Figure Legends

Manuscript Submission Procedure

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Manuscripts should be submitted online through http://dergipark.gov.tr/cumudj. Full instructions and support are available on the website, and a *user ID* and *password* can be obtained at the first visit. All parts of the manuscript (Main Document, Tables, Figures and Supplemental Information) must be available in an electronic format: Microsoft Word or generic RTF are recommended for text and tables; and TIFF or EPS for graphics (see under Figures).

ELEMENTS OF a MANUSCRIPT

1. Title Page

- ***Title page must be*** **uploaded apart from manuscript and should include;**
- -Title
- -Authors (first name, middle initial, surname) e.g. Burak Buldur, DDS, PhD,[a]
- -Authors' addresses (abbreviated) e.g.
- [a] Associate Professor Dr., Department of Pediatric Dentistry, Faculty of Dentistry, Cumhuriyet University, Sivas, Turkey.
- **ALL AUTHORS' ORCID NUMBERS** must be included
- A running title, not exceeding 50 letters and spaces
- Corresponding Author details including name, complete address, phone, fax, and e-mail must be added.

Main Document

The main document includes, in a single electronic file (Word/text file, not pdf).

2. Abstract

- Should not exceed 300 words and should be presented under the following subheadings:

Research Articles: Objectives, Materials and Methods; Results; Conclusions

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3. Keywords

- Up to 5 keywords should be supplied according to **MESH**.

4.Introduction

- This must be presented in a structured format, covering the following subjects, although not under subheadings: succinct statements of the issue in question; the essence of existing knowledge and understanding pertinent to the issue; and the aims and objectives of the research being reported.

5. Materials and methods

- The authors should describe the procedures and analytical techniques and identify names and sources of all commercial products e.g. magnetic attachment (Hyper Slim 5513, Hitachi Metals, Tokyo, Japan)

6. Results

- The authors should refer to appropriate tables and figures and report statistical findings.

7. Discussion

- The authors should discuss the results of the study also state the agreement with other studies and identify the limitations of the present study and suggest areas for future research.

8. Conclusions

- The authors should concisely list conclusions that may be drawn from the research and do not simply restate the results.

9.Acknowledgements

- If the work was supported by a grant or any other kind of funding, supply the name of the supporting organization and the grant number.

11. Conflicts of Interest statement

- Specify any potential conflict of interests, or state no conflicts of interest.

11. References

- References must be identified in the body of the article with superscript Arabic numerals after punctuation marks.
- The complete reference list must be double spaced and in numerical order and should start on a separate page. Only references cited in the text should appear in the reference list.
- Unpublished data or personal communications are not accepted.

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- Figures should be planned to fit the proportions of the printed page (width 17 cm) or one column (width 8 cm) and be legible at this size.
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- Colour and black-and-white photographs should be created and saved at a minimum of 300 dots per inch (dpi).
- Please name each electronic image file. For example, a Figure 1 in jpeg format should be named fig 1. Multipart figures must be clearly identifiable by the file names: fig 1A, fig 1B, fig 1C, etc.

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- The authors should list together on a separate page and include key for symbols or abbreviations used in Figures.

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For various reasons, this kind of free and unrestricted online availability, which we will call open access, has so far been limited to small portions of the journal literature. But even in these limited collections, many different initiatives have shown that open access is economically feasible, that it gives readers extraordinary power to find and make use of relevant literature, and that it gives authors and their works vast and measurable new visibility, readership, and impact. To secure these benefits for all, we call on all interested institutions and individuals to help open up access to the rest of this literature and remove the barriers, especially the price barriers, that stand in the way. The more who join the effort to advance this cause, the sooner we will all enjoy the benefits of open access.

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While the peer-reviewed journal literature should be accessible online without cost to readers, it is not costless to produce. However, experiments show that the overall costs of providing open access to this literature are far lower than the costs of traditional forms of dissemination. With such an opportunity to save money and expand the scope of dissemination at the same time, there is today a strong incentive for professional associations, universities, libraries, foundations, and others to embrace open access as a means of advancing their missions. Achieving open access will require new cost recovery models and financing mechanisms, but the significantly lower overall cost of dissemination is a reason to be confident that the goal is attainable and not merely preferable or utopian.

To achieve open access to scholarly journal literature, we recommend two complementary strategies.

I. Self-Archiving: First, scholars need the tools and assistance to deposit their refereed journal articles in open electronic archives, a practice commonly called, self-archiving. When these archives conform to standards created by the Open Archives Initiative, then search engines and other tools can treat the separate archives as one. Users then need not know which archives exist or where they are located in order to find and make use of their contents.

II. Open-access Journals: Second, scholars need the means to launch a new generation of journals committed to open access, and to help existing journals that elect to make the transition to open access. Because journal articles should be disseminated as widely as possible, these new journals will no longer invoke copyright to restrict access to and use of the material they publish. Instead they will use copyright and other tools to ensure permanent open access to all the articles they publish. Because price is a barrier to access, these new journals will not charge subscription or access fees, and will turn to other methods for covering their expenses. There are many alternative sources of funds for this purpose, including the foundations and governments that fund research, the universities and laboratories that employ researchers, endowments set up by discipline or institution, friends of the cause of open access, profits from the sale of add-ons to the basic texts, funds freed up by the demise or cancellation of journals charging traditional subscription or access fees, or even contributions from the researchers themselves. There is no need to favor one of these solutions over the others for all disciplines or nations, and no need to stop looking for other.

Open access to peer-reviewed journal literature is the goal. Self-archiving (I.) and a new generation of open-access journals (II.) are the ways to attain this goal. They are not only direct and effective means to this end, they are within the reach of scholars themselves, immediately, and need not wait on changes brought about by markets or legislation. While we endorse the two strategies just outlined, we also encourage experimentation with further ways to make the transition from the present methods of dissemination to open access. Flexibility, experimentation, and adaptation to local circumstances are the best ways to assure that progress in diverse settings will be rapid, secure, and long-lived.

The Open Society Institute, the foundation network founded by philanthropist George Soros, is committed to providing initial help and funding to realize this goal. It will use its resources and influence to extend and promote institutional self-archiving, to launch new open-access journals, and to help an open-access journal system become economically self-sustaining. While the Open Society Institute's commitment and resources are substantial, this initiative is very much in need of other organizations to lend their effort and resources.

We invite governments, universities, libraries, journal editors, publishers, foundations, learned societies, professional associations, and individual scholars who share our vision to join us in the task of removing the barriers to open access and building a future in which research and education in every part of the world are that much morefree to flourish. Submitting a paper to CDJ is free of charges. In addition, CDJ has not have article processing charges.

PLAGIARISM and ETHICS

CDJ aims to the highest standards with regard to research integrity and in particular the avoidance of plagiarism, including self-plagiarism. It is therefore essential that authors, before they submit a paper, particular attention should be paid When submitting a paper on CDJ, authors will be prompted as to whether they have read and agree to these guidelines before proceeding further with their submission. They will be asked specifically for an assurance that the paper contains no element of data fabrication, data falsification or plagiarism (including unacknowledged self-plagiarism). Authors are reminded that, where they draw upon material from another source, they must either put that material in the form of a quote OR write it entirely in their own words (i.e. there is no 'middle way'). In both cases, they must explicitly cite the source, including the specific page number in the case of a quote or a particular point. **CDJ uses Ithenticate: Plagiarism Detection Software.**

For the experimental, clinical and drug human studies, approval by ethical committee and statement on the adherence of the study protocol to the international agreements (Helsinki Declaration revised 2008) are required. In experimental animal studies, the authors should indicate that the procedures followed were in accordance with animal rights and they should obtain animal ethic committee approval. The Ethic Committee approval document should be submitted to the Cumhuriyet Dental Journal together with the manuscript.

The approval of the ethic committee, statement on the adherence to international guidelines mentioned above and that the patients'informed consent is obtained should be indicated in the "Materials and Methods" section and is required for case reports whenever data/media used could reveal identity of the patient. The declaration of the conflict of interest between authors, institutions, acknowledgement of any financial or material support, aid is mandatory for authors submitting manuscript and the statement should appear at the end of manuscript. Reviewers are required to report if any potential conflict of interest exists between reviewer and authors, institutions.

Cumhuriyet Dental Journal: 2020; 23(2)
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CONTENTS

Cumhuriyet Dental Journal: 2020; 23(3)
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Doi:10.7126/cumudj.806860

Editorial

The Editor's recommendation of this issue's article to readers

COMPARISON OF SUBJECTIVE ESTHETIC PERCEPTIONS OF DENTISTS WITH DIFFERENT SEX AND CLINICAL EXPERIENCES WITH OBJECTIVE DENTOLABIAL ESTHETIC MEASUREMENTS

I am pleased to inform you that I have chosen this article by Geduk *et al*.[1] as Editor's Choice for this issue of 2020.

Planning dental and gingival analyzes after the facial, dentolabial and phonetic parameters is critical to achieve successful esthetic results.

This article revealed that there is no consensus between esthetically objective findings and subjective views.

Happy readings in the third issue of 2020!

Burak Buldur

Co-Editor-in-Chief

REFERENCE:

1. Geduk ŞE, Şahin O, Velioğlu N. Comparison of Subjective Esthetic Perceptions of Dentists with Different Gender and Clinical Experiences with Objective Dentolabial Esthetic Measurements. Cumhuriyet Dent J 2020;23:3:209-220.

How to Cite: How to Cite: Buldur B. Editorial: Co-Editor-in-Chief's recommendation of this issue's article to readers. Cumhuriyet Dent J. 2020;23:3;153.

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e-ISSN 2146-2852
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Original research

EVALUATING THE ACCURACY OF TOOTH-SUPPORTED VS MUCOSA-SUPPORTED 3D-PRINTED SURGICAL GUIDE IN DENTAL IMPLANT PLACEMENT (CROSS-SECTIONAL STUDY)

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ABSTRACT

Objectives: This study aims to estimate the accuracy of implant insertion using stereolithographic 3D-printed surgical guides; two types were evaluated: tooth-supported and mucosa-supported guides.

Materials and methods: 9 patients were enrolled in this study, 5 males and 4 females, mean age: 49.33 years. 12 implants were inserted using tooth-supported guides While 12 implants were inserted using mucosa-supported guides, deviations between the virtual planned implants and the placed implants were calculated after matching the pre- and post-operative CBCT. Matching process was performed using digital software (Blue Sky Plan); angular deviation, deviation at the entry point and apex of the implant were measured. An independentsamples t-test was performed to compare the two groups using SPSS version 25.

Results: The mean angular deviations were 3.67±1.61 degrees and 5.46 ± 2.41 degrees with the tooth-supported and mucosa-supported surgical guides respectively, and the mean three-dimensional deviations were 0.70±0.35 mm and 1.38±0.41 mm at the entry point, 0.99 ±0.52 mm and 1.86 ±0.51 mm at the apex, with the tooth-supported and mucosa-supported surgical guides respectively.

Conclusions: The results of this study showed that the accuracy of the tooth-supported guide is superior to the mucosa-supported guide.

Keywords: Accuracy, dental implants, stereolithography, surgical guide.

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INTRODUCTION

Oral rehabilitation with implant supported prostheses is one of the most common predictable procedures that has become a more widespread method in daily dental practice.[1,2] Dental implants have been used since 1960s.[3] Precise preoperative planning is essential for the clinical success of implant placement, aesthetic outcome and long-term predictability of the future prosthesis. This subject is very important with multiple missing teeth, in which landmarks from adjacent or contralateral teeth are missing. The anatomical variables such as the mandibular canal, mental foramen, submandibular fossa, maxillary sinus and possible lesions in the jaws need to be considered before implant insertion.[4]

Practitioners have generally used panoramic radiographs for implant placement; however, this method of assessment has some disadvantages such as distorted images.[5]andincapability of displaying the bone width.[6]

Due to the introduction of cone beam computed tomography, preoperative three-dimensional planning has become popular. Nowadays new technologies are influencing implant placement procedures and enforce our capability in inserting implants according to the virtual planned location.[7]

Computer-Aided Implantology (CAI), or guided surgery, aims to achieve precise implant positioning, avoid injury of vital anatomical structures, and reduce surgical time especially with flapless approach.[8], Less morbidity and much more comfort to the patient can be attained.[9-12] Furthermore, a study has found that guided implant placement could be an alternative to bone grafting procedures.[13] On the other hand, guided surgery is a sensitive procedure that requires several phases; errors may arise in any phase and lead to the final cumulative error.[14] These errors result in deviations between planned and inserted implants.

The purpose of the present study is to assess and analyze the clinical reliability of implant placement using two types of 3D-printed guides, including tooth-supported and mucosa-supported guides, and to answer the question about how the type of guide support affects the efficacy and accuracy of implant insertion.

MATERIALS AND METHODS

An approval of the Scientific Research Committee of Damascus University has been obtained, dated on 3/9/2018 with an ID: 3387 for this cross-sectional study.

The study was carried out at the Department of Oral & Maxillofacial Surgery, Faculty of Dentistry, Damascus University.

Nine patients (5 males and 4 females) were enrolled in this study. 24 implants (implant direct – legacy3) were inserted to replace missing teeth. Patients with poor oral hygiene, systemic conditions, previous irradiation therapy, habit of smoking, bone deficiencies and parafunctional habits were excluded.

All patients have signed written informed consents.

In this study the steps below were followed:

1- A radiographic template was fabricated using a radiopaque acrylic material (Acryline X-ray dvt – Anax dent) which meets the aesthetic and prosthetic demands. In the case of totally edentulous patient, the radiographic template was created from the existing denture.

2-Data acquisition: a primary CBCT scan of the patient's jaw was performed using (Vatechpax – I3d), and the radiographic templates were included in the scans. All the CBCT data was transformed into Digital Imaging and Communications in Medicine (DICOM) files. An impression of the patient's arches was taken, poured and scanned by a lab scanner (MEDIT T300) to produce a (STL) file.

(DICOM) and (STL) files were imported to computer software (Blue Sky Plan – version 4.2.5 – United States) and were merged together.

3- Digital 3D planning: with Blue Sky Plan, implants were virtually planned while taking the anatomical landmarks and prosthetic desire into consideration. A surgical guide was also virtually designed (Figure 1).

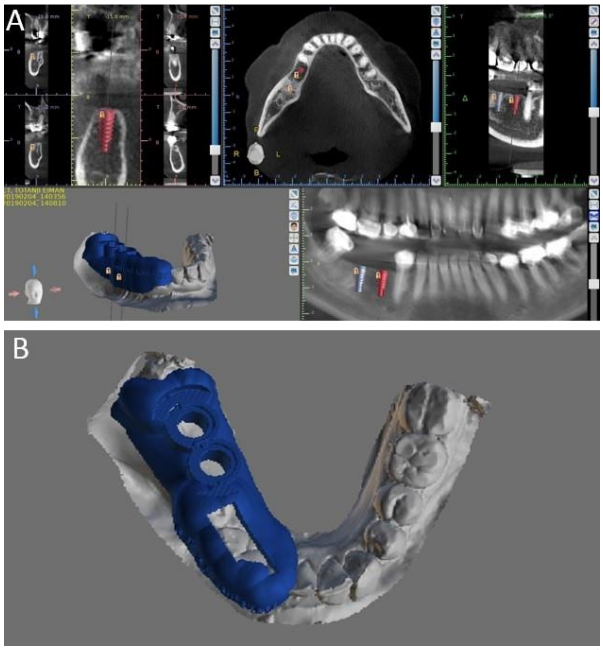

Figure 1: (a) virtual planning of the implants. (b) Virtual design of the surgical guide

4- Surgical guide fabrication: Stereolithography process was used to create the surgical guide from virtual 3D model via 3D printer (ZENITH, Dentis, Daegu, Korea). The angulation and position of each implant as planned with Blue Sky Plan was transferred to the 3D printed surgical guide.

5- Surgical phase:all surgical steps were performed by the same surgeon under local anesthesia using Lidocaine with epinephrine as a vasoconstrictor. (Figure 2A) (Figure2B).

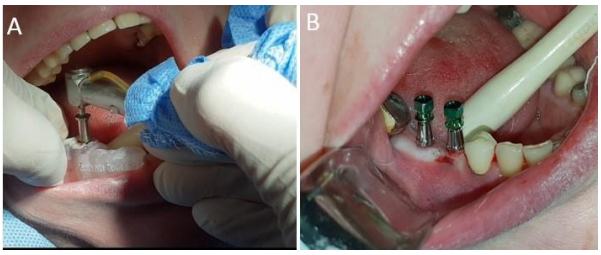

Figure 2: (a) Drilling through the surgical guide. (b) Postoperative view of the inserted implants.

6- Secondary CBCT scan of the patient's jaw was performed using the same primary CBCT parameters.

7- Superimposition of the preoperative and the postoperative CBCT scans was done using Blue Sky Plan (Figure 3), (Figure 4).

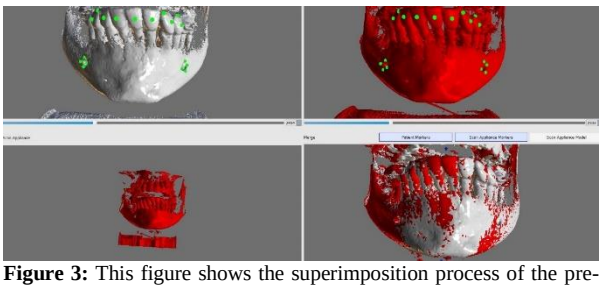

Figure 3: This figure shows the superimposition process of the pre-operative and post-operative CBCT.

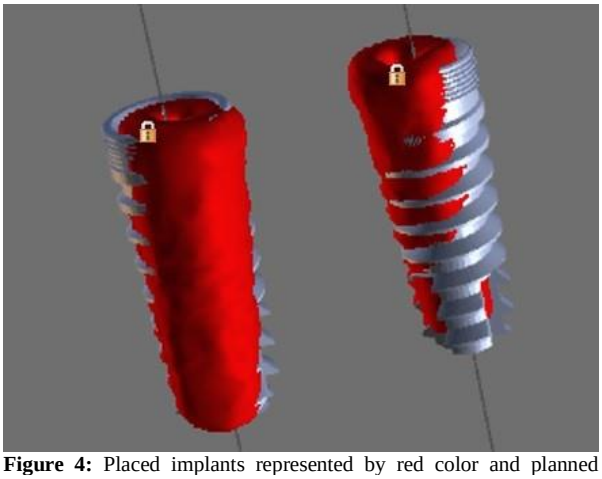

Figure 4: Placed implants represented by red color and planned implants represented by grey color.

8- Calculation of the deviations between virtual and placed implants was done. The deviations were measured at the level of entry point and apex of the implant. Angular deviation was measured as well.

Statistical Analysis

An independent samples t-test was performed to compare the two groups using SPSS version 25.

RESULTS

No complications occurred during implant placement.12 implants were placed using tooth-supported surgical guides (group 1) and 12 were placed using mucosa-supported surgical guide (group 2).

Data are mean ± standard deviation. An independent samples t-test was performed to determine if there were statistically significant differences in angular and lateral deviations between the two mentioned groups; results were considered significant at $p<0.05$.

The mean angular deviations between planned and inserted implants were 3,67°±1.61° and 5.46°± 2.41° with the tooth-supported and mucosa-supported surgical guides respectively. The mean lateral deviations were 0.70±0.35 mm

and 1.38±0.41 mm at the entry point,0.99 ±0.52 mm and 1.86 ±0.51 mm at the apex, with the tooth-supported and mucosa-supported surgical guides respectively. (Table 1)

Table 1. The means, standard deviations, minimum and maximum deviations of the angular deviation and of the linear deviations determined at the level of entry point and implant apex.

Variables	Type of support	Mean	SD	Min	Max	95% CL	
						Min	Max
Deviation at entry point (mm)	tooth	0.70	0.35	0.30	1.50	0.48	0.92
	mucosa	1.38	0.41	0.70	2.20	1.12	1.63
Deviation at apex(mm)	tooth	0.99	0.52	0.40	2.00	0.66	1.33
	mucosa	1.86	0.51	0.70	2.70	1.53	2.18
Angular deviation (°)	tooth	3.67	1.61	1.00	6.00	2.64	4.69
	mucosa	5.46	2.41	2.00	9.00	3.93	6.99

A Significant difference of 1.79° (95% CL, 0.06 to 3.53), $t = 2.141$, $p = 0.044$was found between the two groups for the angular deviation. For the deviation at the entry point there was a significant difference of 0.68 mm (95% CL, 0.35 to 1.00), $t = 4.347$, $p < 0.001$ between the two groups. There was also a significant difference of 0.87 mm (95% CL, 0.43 to 1.31), $t = 4.100$, $p < 0.001$between the two groups for the deviation at the apex. (Table 2)

Table 2: An independent-samples t-test was performed to make Statistical Comparison of Deviation Differences Between tooth-supported guide group and mucosa-supported guide group, statistical significance level was established at p<0.05

Variables	Difference in means between the two groups	T	P Value	95% CL	
				Minimum	Maximum
Deviation at entry point	0.68 mm	4.347	0.000	0.35	1.00
Deviation at apex	0.87 mm	4.100	0.000	0.43	1.31
Angular deviation	1.79°	2.141	0.044	0.06	3.53

DISCUSSION

New technologies in dental implant planning methods have changed our procedures and made it possible to transfer the virtual plan into the surgical field.[7]3D printed guide is one of the latest technologies in computer-guided surgery. However, deviation from the virtual planning phase is possible.[8] Several means have been used to evaluate and measure thiserror.[15-18]Nowadays,Dicom files matching is the standard method used to assess the deviation between the planned and the clinically inserted implants.[19]

To evaluate the accuracy of implant insertion some points should be taken into account:

Deviation at the entry point

Deviation at the apex

Angular deviation.[20]

In an in-vitro study Turbush *et al.*[21] described the use of Stereolithography to fabricate 30 acrylic resin mandibles: 10 mandibles were modified by adding teeth, and10 mandibles were modified with soft acrylic resin to simulate the mucosa. 150 implants were inserted using bone-supported, tooth supported, mucosa supported surgical guides and superimposition of DICOM files (preoperative and postoperative) were performed using 3D software to calculate the deviations between planned and inserted implants. The mean deviations in position at the neck and apex were 1.00 ±0.33 mm and 1.15 ±0.42 mm for the tooth supported guide, 1.47 ± 0.43 mm and 1.65 ± 0.48 mm, for the mucosa supported guide, 1.08 ± 0.33 mm and 1.53 ± 0.90 mm for the bone supported guide respectively. However, the angular deviation was 2.26 ± 1.30 degrees for the tooth supported guide, 2.29 ± 1.28 degrees for the mucosa supported guide, 2.17 ± 1.02 degrees for the bone supported guide. This study suggests that there is a slightly better outcome for the tooth supported guide in comparison with the mucosa supported guide.

Concerning the accuracy of surgical guide for dental implant placement based on the type of supporting tissue, a systematic review.[20] figured out that tooth-supported guide has better accuracy compared to bone / mucosa-supported guide. This systematic review revealed that the mean deviation at the entry point was 0.84, 1.07, 1.43 mm, and at the apex it was 1.15, 1.64, 1.87 mm for tooth-, mucosa-, and bone-supported guides, respectively. Comparable results were reported in our study which noted that, regarding the accuracy, tooth supported guides showed lower deviations than mucosa supported guides.

Several factors contribute to the relative inaccuracy of the mucosa supported guide; stabilization and positioning errors have the most significant effect.[22]

The thickness of the mucosa had also been noted as one of the factors contributing to the accuracy of implant insertion with mucosa supported guide, and the deviations increase when the mucosa is thicker.[23, 24]

CONCLUSIONS

The results of this study show that there is a correlation between the guide supporting type and the accuracy of implant placement. The final outcome is the sum of all errors that could happen during the procedure. Furthermore, the mucosa-supported guide maybe less accurate than the tooth-supported guide.

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CONFLICTS OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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Original research

THE INFLUENCE OF DIFFERENT TORQUE SETTINGS ON THE AMOUNT OF APICALLY EXTRUDED DEBRIS DURING ROTARY INSTRUMENTATION

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ABSTRACT

Objectives: This *in vitro* study was designed to evaluate the effect of low- and high-torque settings on the amount of apically extruded debris during canal preparation with the ProTaper Universal (PTU) system.

Materials and Methods: Forty extracted mandibular premolars were selected and randomly divided into two groups (n=20). Each root canal was prepared according to the manufacturer's instructions, using SX, S1, S2, F1, F2, and F3 at low-torque settings and high-torque settings. The apically extruded debris was collected into preweighed Eppendorf tubes. The weight of extruded debris was determined, and data were analyzed using the Mann-Whitney *U* test at a significance level of $p<0.05$.

Results: No significant difference was observed between the groups ($p>0.05$). The PTU system produced the higher mean extrusion value at high-torque settings.

Conclusions: Under the conditions of this study, as no difference among the different torque settings in terms of the amount of extruded debris were noted, it is possible to suggest that clinicians should choose the most appropriate settings for each case in clinical practice.

Keywords: Endodontics, root canal preparation, torque.

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INTRODUCTION

Dentin chips, pulp tissue, microorganisms, and irrigants may be extruded into the periapical tissues during root canal instrumentation. The apical extrusion may cause periapical inflammation and postoperative pain.[1,2] Several factors, such as type of the file, instrumentation technique and kinematic, apical preparation size, end-point of the instrumentation, canal or apical foramen size, canal curvature, irrigation solutions and techniques, and type of needle tip that may affect the amount of apically extruded intracanal materials, have been investigated in many studies which have shown that all conditions result in apical extrusion.[3-10] However, the amount of debris and irrigant extruded apically may differ according to these factors, and minimizing the apical extrusion can reduce the incidence of postoperative pain.

Torque is another changeable parameter during the instrumentation of root canals with rotary nickel-titanium (NiTi) instruments and is especially important to reduce the incidence of instrument locking, deformation, and separation. High torque may cause the instrument to lock and, consequently, cause deformation and separation.[11] Different torque settings are recommended for different type and size instruments by the manufacturers because each instrument has a specific ideal torque. Low-torque values are usually recommended for the smallest and less tapered instruments, but the largest and more tapered ones can be used with high-torque values. Theoretically, the instrument becomes more active when used with high-torque values. However, the cutting efficiency of the instrument would be reduced with low-torque, and progression of the instrument in the canal would be more difficult.[12]

Several studies have investigated debris extrusion with different NiTi file systems.[13-16] The ProTaper Universal (PTU; Dentsply Maillefer, Ballaigues, Switzerland) is one of the most widely used rotary systems, and it is characterized by its convex, triangular cross-sectional design, positive rake angle, and progressive taper. Some studies have shown that instrumentation with the PTU system resulted in significantly more debris extrusion than with other NiTi file systems.[14,16,17] These file systems can be used in a wide range of torque settings during instrumentation, according to the manufacturer.[18,19] To the best of our knowledge, no published studies have investigated the effect of different torque settings on apical extrusion of debris after root canal preparation using PTU system. Therefore, the purpose of the present study was to compare the amount of debris extruded apically after instrumentation of root canals using the PTU system at low- or high-torque settings. The null hypothesis tested was that there is no significant difference between the low- and high-torque settings groups in terms of apically extruded debris.

MATERIALS AND METHODS

The research design was approved by the Clinical Research Ethics Committee of Sivas Cumhuriyet University in Sivas, Turkey (2016-01/07). Extracted, straight, single-rooted human mandibular premolars with a single canal were used. Roots with resorption, fractures, or open apices were excluded. The radiographs from the buccolingual and mesiodistal angles were taken to evaluate the root canal anatomy. Soft tissue and calculus were removed from the external root surfaces with hand instrumentation, and all teeth were stored in sterile saline until used. The teeth were decoronated with a diamond disc to obtain 17 mm root canal length. Apical patency was assessed with a size 10 K-file (Dentsply Maillefer). Working length for each canal was established by subtracting 1 mm from the length where a size 10 K-file was visible at the major foramen. Teeth in which a size 15 K-file (Dentsply Maillefer) did not easily access the working length and did not extrude beyond the minor foramen were included in the study. 2 groups of 20 teeth each were finally formed in order to have 0.80 power (1 - beta), beta of 0.20, and an alpha error probability of 0.05. The selected teeth, according to these criteria, were randomly distributed into low- and high- torque setting groups by flipping of a coin.

The experimental model, similar to that described in a study[20], was used to evaluate debris extrusion. The covers of the Eppendorf tubes were

separated, and an electronic balance (Precisa XB 220A; Precisa Inst., Dietikon, Switzerland), having an accuracy of 0.0001 g, was used to measure the weights of the empty tubes. Three successive measurements were obtained for each tube, and the average value was recorded. Holes were created on the covers of the Eppendorf tubes, and each root was fixed through the cover by using hand pressure. A 27-gauge needle was inserted into the cover to balance the internal and external pressures, and then each cover with the root and needle was attached to the tubes. The tubes were placed into vials, which were coated with an aluminum foil to avert the operator from seeing extrusion.

In all groups, instrumentation was performed with the PTU system by using a torque-controlled electric motor (X-Smart; Dentsply, Maillefer) at 300 rpm. The lowest and highest torque values for each instrument (Table 1), determined according to the manufacturer's recommendation, were used for the root canal preparations.[18]

Table 1. Lowest and highest torque settings recommended by the manufacturer for each ProTaper Universal file

	SX	S1	S2	F1	F2	F3
Lowest torque settings (Ncm)	3	2	1	1.5	2	2
Highest torque settings (Ncm)	4	3	1.5	2	3	3

However, the 1.5 Ncm torque proposed by the manufacturer for the F1 and S2 instruments was not included in the settings of the X-Smart motor. Therefore, torque was adjusted to 1.6 Ncm (to avoid falling below the recommended minimum torque value of F1 instrument) for the F1 instrument in the low-torque group and to 1.4 Ncm (to avoid exceeding the recommended maximum torque value of S2 instrument) for the S2 instrument in the high-torque group. The instrumentation sequence was SX (2/3 of the working length), S1–2 (full working length), and F1–3 (full working length). After the use of each instrument, apical patency was confirmed to avoid an apical blockage. Instruments were used to prepare only four canals. A single operator performed all instrumentation to avoid variation and eliminate bias. The root canals were irrigated using a VATEA peristaltic pump (ReDent-Nova, Ra'anana, Israel) to obtain a 2 mL/min flow rate of the irrigation solution. After each instrument change, 2 mL of bidistilled water were used as an irrigant, and each canal was irrigated with a total volume of 13 mL irrigant during preparation.

After the preparation was performed, the roots were washed with 1 mL of bidistilled water into the tubes to collect the debris adherent to the root surface. The tubes were placed in an incubator at 37°C for 15 days for irrigant evaporation before weighing the tubes which included the dry debris. The weight of each tube was measured three times consecutively, and the average value was recorded. The weight of extruded debris was calculated by subtracting the weight of the empty tube from the final weight. All the initial and final weights of the eppendorf tubes were measured by a second operator.

Statistical analysis was performed with IBM SPSS Statistics version 22.0 (IBM SPSS Statistics, Inc., Armonk, NY, USA). The normality of the data was assessed by the Kolmogorov-Smirnov test and the amount of extruded debris was analyzed statistically by using the Mann-Whitney *U* test. The level of significance was set at $p<0.05$.

RESULTS

Debris extrusion was recorded in both groups. The mean values and standard deviations of the amount of apically extruded debris are shown in Figure 1. The quantity of debris extrusion was 0.00027 ± 0.000156 g for the high-torque group and 0.00022 ± 0.000144 g for the low-torque group. The mean debris extrusion value of the PTU instruments in the high-torque group was higher than in the low-torque group, but no significant difference was found between the groups ($p=0.227$).

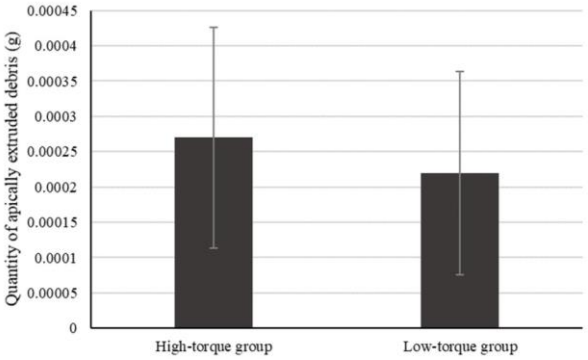

Figure 1. The quantity of apically extruded debris for each group (error bars correspond to the standard deviation). Statistically no significant difference between the groups was observed (p=0.227).

DISCUSSION

Fracture of rotary instruments can occur due to flexural or torsional fatigue.[21] Fracture caused by torsional fatigue occurs when the tip, or any other part of the file is locked in the canal while the shaft continues to rotate.[22] To prevent this type failure, different torque settings are recommended for each instrument by the manufacturers. Although torque has an influence on the cutting efficiency and instrument progression in the canal, studies have usually investigated the effect of torque settings on the failure of rotary NiTi instruments.[23-25] The effect of torque settings on the crack formation in root dentin[26,27] and the cleaning efficiency of the rotary instruments[28] have also been investigated in some studies. To our knowledge, the influence of different torque settings on the apical extrusion of debris occurring after canal instrumentation with PTU system have not been tested and reported in the literature. In the present study, the amount of debris extruded apically after instrumentation of root canals using the PTU system at low- or high-torque settings was evaluated and the difference between the groups was not statistically significant. Therefore, the null hypothesis was accepted.

Many studies have shown that the PTU system is associated with more debris extrusion than other NiTi file systems, and according to these previous studies, larger apical tapers of the PTU instruments (F1: 7%, F2: 8%, and F3: 9%) may result in more aggressive preparation of the root canals, which might explain the increased debris production and extrusion with this system.[16,17,29] Therefore, in the present study, the effects of low- and high-torque settings of the PTU system on the amount of apically extruded debris were evaluated and apical debris extrusion occurred during canal instrumentation with PTU regardless of the different torque settings that were used. Although there was no significant difference among the low- and high-torque settings, when the average debris extrusion values of the different torque settings were examined, high-torque settings resulted in more debris extrusion than low-torque settings. The cutting ability increases with high-torque settings[12], and the greater debris extrusion in the high-torque group may be related to increased cutting efficiency and debris production. In addition, the operator noticed that the screw-in tendency of the PTU files increased at high torque settings. The strong screw-in tendency may cause unwanted penetration of the instrument beyond the apical foramen and torsional stress increase at the moment of screw-in.[30,31] The motor starts to rotate counter-clockwise at low-torque settings when these stresses increase. This action may reduce transportation of debris toward the apex by preventing over-instrumentation risk due to the screw-in tendency of the instruments.

In order to avoid variation and eliminate bias during the assessment of apically extruded debris, standardization of the methodology used is necessary. In the present study, teeth were selected taking into account their type, number of canals, curvature and the initial foramen diameter. Working lengths of the samples was standardized. All instrumentation and irrigation procedures were performed by a single operator to reduce operator variability and a second operator who was blinded to the group assignment performed all the initial and final measurements of the Eppendorf tubes. Bidistilled water was used for the irrigation of root canal to avoid potentially misleading results from the crystallization of sodium hypochlorite.[32] The method proposed by Myers and Montgomery[20] was used to evaluate debris extrusion. This testing model did not include a material such as floral foam in the simulation of the resistance of periapical tissues. The usage of floral foam may affect the results due to absorption of some debris and irrigant

when used as a physical barrier. For this reason, no attempt was made to simulate periapical resistance in this study. Thus, the results cannot be directly extrapolated to the clinical environment. It has also been reported that, the differences in dentin microhardness of human teeth used might affect the results of the studies. In teeth with lower hardness, residues may be more easily extruded into the periapical tissues.[33]

CONCLUSIONS

Under the conditions of this study, the PTU system was associated with apical debris extrusion at both torque settings and as no differences among the different torque settings were noted, it is possible to suggest that clinicians should choose the most appropriate settings for each case in clinical practice.

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CONFLICTS OF INTEREST STATEMENT

The authors declare that there is no competing interest.

Farklı Tork Ayarlarının Rotary Enstrümantasyon Sırasında Apikalden Taşan Debris Miktarına Etkisi

ÖZ

Amaç: *Bu in vitro çalışma, ProTaper Universal (PTU) sistemle kök kanal preparasyonu sırasında düşük ve yüksek tork ayarlarının apikalden taşan debris miktarına etkilerini değerlendirmek için planlandı.* ***Gereç ve Yöntemler:*** *40 adet çekilmiş mandibular premolar diş seçildi ve rastgele iki gruba ayrıldı (n=20). Her bir kök kanalı üreticinin önerilerine göre düşük ve yüksek tork ayarlarında SX, S1, S2, F1, F2 ve F3 kullanılarak prepare edildi. Apikalden taşan debris önceden tartılmış Eppendorf tüplerine toplandı. Taşan debris ağırlığı belirlendi ve veriler Mann-Whitney U-testi kullanılarak 0,05 anlamlılık düzeyinde analiz edildi.* ***Bulgular:*** *Gruplar arasında anlamlı fark gözlenmedi (p>0,05). PTU sistem yüksek tork ayarlarında daha yüksek ortalama ekstrüzyon değeri ortaya koydu.* ***Sonuç:*** *Bu çalışmanın koşulları altında, farklı tork ayarları arasında taşan debris miktarı yönünden herhangi bir fark olmadığı için, klinisyenlerin klinik uygulamada her vaka için en uygun ayarları seçmeleri gerektiğini önermek mümkündür.* ***Anahtar Kelimeler:*** *Endodonti, kök kanal preparasyonu, tork.*

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Original research

THE EFFECT OF A VARNISH CONTAINING SELF-CURING RESIN ON THE SOFTNESS OF TWO TYPES OF TISSUE CONDITIONERS

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ABSTRACT

Objectives: One of the limitations of tissue conditioners (TC) is the gradual hardening of the material in a short time after insertion in the mouth. This study aimed to determine the softness of two different tissue conditioners with and without the coating made up of 1,1,1trichloroethan and self-curing acrylic resin.

Materials and Methods: In this experimental study, Acrosoft (Marlic, Tehran, Iran) and GC (GC corporation, Tokyo, Japan) tissue conditioners were examined. 28 discs of 20 x 3 mm dimensions were prepared for each tissue conditioner (n=14). Half of the samples in each group were coated with varnish coating made up of 1,1,1trichloroethan and self-curing acrylic resin. The hardness of all samples was measured at five intervals of 1,3,7,14, and28 days by a Shore-A Durometer with a conical indenter. The data were analyzed by descriptive statistics and Friedman analyses. $P<0.05$ was considered statistically significant.

Results: The mean hardness of the GC and Acrosoft tissue conditioners on days 1, 3, 7, 14, and 28 in both varnish-coated and non-varnish-coated groups were statistically different and Acrosoft tissue conditioner was harder than the GC. In the paired mean hardness comparison on days 1, 3, 7, 14, and 28 in the GV and G0 groups: this trend was the same in AV and A0 groups. The comparison of hardness in the GV and G0 groups at each time interval indicated that only on day 3, the control group (G0) was harder than the surface coating group (GV). The comparison of the hardness in the AV and A0 groups showed that on days 3 and 7, the hardness in the control group (A0) was higher than the surface coating group (AV).

Conclusions: The varnish containing self-curing resin can soften the Acrosoft and GC tissue conditioner in a short time. Moreover, this varnish can be clinically applied in the borders between the soft liner and acrylic denture, which is usually the starting point for debonding.

Keywords: Denture liner, self-curing resin, tissue conditioning.

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INTRODUCTION

Tissue conditioners (TCs) are soft and flexible materials used for the treatment of inflammation, tissue irritation, and functional molding. These materials are commonly used as temporary reline material, in tissue repair stage after implant insertion and in maxillofacial dentures.[1] Moreover, these materials are used to evenly disperse the forces applied to soft tissues during function; their resilience can absorb force during chewing and allows chewing forces to spread widely over the residual alveolar bone. When mucosal pain is associated with the rigid denture base, the soft lining materials can act as a cushion.[2,3]

Tissue conditioners are composed of a powder and liquid system with a powder containing Poly Methyl methacrylate (PMMA) polymer, a liquid containing ethyl alcohol and an aromatic ester that improves the plasticity of the material.[4,5] Ideally, for adequate cushioning, a tissue conditioner should be replaced every 3-4 days.[5] The limiting factor for the use of tissue conditioners is the effect of the oral environment on the physical properties of the substance. The moist environment of the oral cavity dissolves ethanol and ester into saliva and absorbs water in the polymeric phase.[4] Loss of the plasticity agent causes a gradual hardness of tissue conditioners, properties such as surface integrity and viscoelasticity are affected, and the lifespan of the material is reduced, leading to the loss of functionality in the material.[4]

Loss of surface integrity and the surface porosity gives rise to the microbial biofilm accumulation and pathological reactions. Various strategies have been proposed to prevent biofilm accumulation, such as mixing tissue conditioner with antifungal agents or using a coating material to block the surface porosity of the material.[1] Up to now, various materials have been used as surface coatings to coat the surface porosities of tissue conditioner, and various studies have been conducted on the extent of their influence on tissue conditioners. In a study by Casey and Scheer[7], it was reported that a tissue conditioner with monopoly coating can extend the lifespan of the material by up to 30 days and sometimes up to one year, due to the fact that this coating maintains the flexibility of the material for a long time by protecting the surface material, which restricts the growth of microorganisms.

Deminguez *et al*.[8] found that tissue conditioners coated with monopoly gradually lose their alcohol in the laboratory environment but do not absorb water, thereby maintaining their flexibility and reducing the growth rate of the microorganism.

Gronet's[9] study showed that the resilience of the tissue conditioner coated with monopoly or Palaseal improved, although different tissue conditioners responded differently to the surface coating. This discrepancy may be due to differences in the adhesion of the surface coating with different tissue conditioners or differences in the components of tissue conditioner such as alcohol or ester percentage. Malmstrom[1] observed a marked decrease in the rate of surface deterioration and loss of softness by covering the surface of the GC tissue conditioner with monopoly and Palaseal. Another material introduced by Zarb *et al*.[6] to block surface porosities and reduce biofilm accumulation on tissue conditioner is the combination of 1,1,1-trichloroethane with self-curing resin.

Given that all studies on surface coatings are industrial, no study was found to show that the varnish introduced by Zarb *et al*.[6] is desirable in terms of softness and clinical application. On the other hand, studies are conducted on fully laboratory environments and saliva present in the oral environment that results in a difference in the solubility of the material compared to conventional environments.[4] Therefore, this study investigates the effect of a custom-made varnish introduced by Zarb *et al*.[6] on two types of tissue conditioners including GC America and Acrosoft TC (Marlic, Iran) in the medium containing artificial saliva. The reason for using GC America tissue conditioner is its common usage by clinicians and the reason for using Acrosoft Iran is its availability. Therefore, according to the above-mentioned descriptions, the purpose of this study was to investigate the effect of a varnish made

from the combination of self-curing acrylic resin and 1,1,1-trichloroethane solution on the softness of two commercial types of tissue conditioners including GC America and Acrosoft Iran.

MATERIALS AND METHODS

This study was an experimental interventional study. The study protocol was approved by the Ethics Committee of Research Council of Tabriz Dental School, Tabriz, Iran (approval number: IR.TBZMED.REC.1394.863). All the procedures of the study were performed based on the Declaration of Helsinki.

GC tissue conditioner (GC Corporation, Tokyo, Japan, LOT 1212111) was prepared according to the manufacturer's instructions as 1 unit of powder to 2 units of liquid (LOT 1212111). Thus, 2.4 g of the powder was taken by the cup and added to 2 ml of the liquid. The resulting mixture was stirred with a spatula for 30-60 seconds to make it homogeneous. Acrosoft tissue conditioner (AcrosoftTC1, Marlic, Tehran, Iran, LOT: UTC1 3135-1) was also added, according to the manufacturer's instructions, as 1 volume of powder (LOT: PTC1 3005-1) (about 2.2 g) to 4 units of liquid (LOT: LTC 1 3006) measured by a dropper (about 1.8 g) and stirred for 30 seconds with a spatula to make it uniform. After 1-2 minutes of preparation, both types of tissue conditioners were placed on a clean glass slab. After inserting 3 mm of thick acrylic stops, a second glass slab was applied to the mixture/composition until a thickness of 3 mm was obtained from each tissue conditioner (Fig 1abc).

Figure1-a. The GC tissue conditioner located between two glass slabs with green acrylic stops,

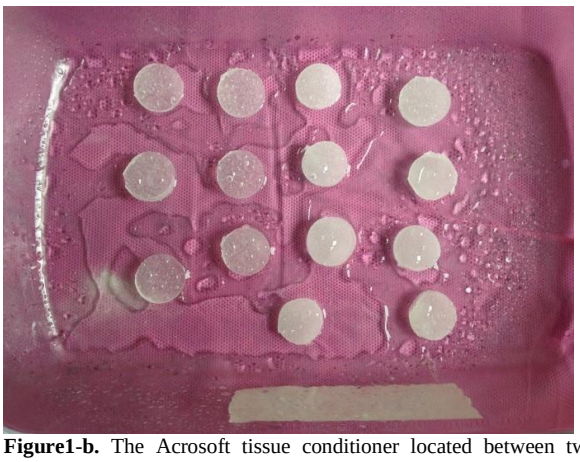

Figure1-b. The Acrosoft tissue conditioner located between two glass slabs with green acrylic stoppers,

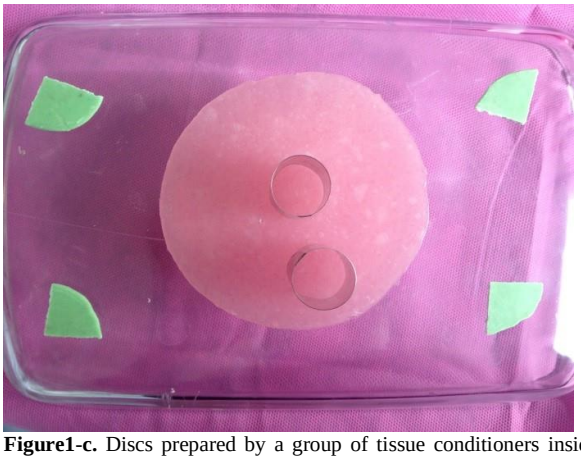

Figure1-c. Discs prepared by a group of tissue conditioners inside artificial saliva solution.

The tissue conditioner was left in the same state for 10-15 minutes to allow the slabs to be separated. Then, with 20-mm-diameter aluminum molds, 28 discs of 20 x 3 mm dimensions were prepared for each tissue conditioner.

To prepare the varnish, 50 ml of 1,1,1-trichloroethane solution (402877-Sigma-Aldrich, St. Louis, USA) was poured into a closed glass bottle with 3ml of self-curing acrylic resin powder (Triplex cold Ivoclar Vivadent Inc. USA). The varnish introduced by Zarb *et al.*[6] was obtained from the combination of 50ml of the 1,1,1-trichloroethane solution with 2ml of acrylic resin powder. Since the resulting compound is required to have glycerin consistency, the powder should be added as needed in case of inadequate viscosity. In this study, we obtained the desired concentration with 3ml of self-curing acrylic resin powder. The mixture was kept in a closed glass for 24 hours to dissolve the powder in the liquid completely.

Hardness of all samples was measured at 5 intervals of 1,3,7,14, and 28 days by a Shore-A

Durometer (TECLOCK, JIS K 6301A, Osaka, Japan) with a conical indenter. We coated all surfaces of 14 of the 28 discs prepared in each of the two types of GC and Acrosoft tissue conditioner with varnish (Group 1 and Group 2). The impregnation process was performed in three steps (to impregnate all surfaces correctly and completely) with a 5-minute interval using a soft brush. The 14 subsequent discs in both GC and Acrosoft tissue conditioners were not impregnated to the varnish as the control group (Group 3 and Group 4). All 4 groups were housed in separate containers in artificial saliva solutions (Hypozalix: Biocodexinc, Paris, France).

Then, the softness of all samples was measured at 5 intervals of 1, 3, 7, 14, and 28 days by a Shore-A Durometer (TECLOCK, JIS K 6301A, Osaka, Japan) with a blunt-pointed indenter of 0.8 mm in diameter which tapers to a cylinder of 1.6 mm and has an inserted scale (0-100). It was measured by applying a fast and intense pressure to the sample, and recording the largest digit.

Statistical Analysis

Finally, the data obtained from the study were analyzed by descriptive statistics (percentage, Mean ± SD) and Friedman analysis in SPSS.17. In this study, p-values of less than 0.05 were considered statistically significant.

RESULTS

The samples of each study group were tested by Durometer after immersion in artificial saliva at different intervals. Table 1 shows the mean surface hardness score at these different intervals.

• Time impact evaluation:

After Kolmogorov-Smirnov test, due to data abnormality (p-value <0.007), Friedman test was run to compare the hardness of the samples on different days. Friedman test showed a statistically significant difference between the mean hardness of the GC and Acrosoft tissue conditioners on days 1, 3, 7, 14 and 28 in both varnish-coated and non-varnish-coated groups (p-Value < 0.05) (Table 1 and 2, Fig 2 and 3).

Table 1. Mean± standard deviation of the hardness of GC tissue conditioner at 5 different time intervals.

group		Mean	Std. Deviation	Mann-Whitney U Statistic	p-Value
Day1	G0*	7	.0	57	0.056
	GV*	8	1		
Day3	G0	15	2.05	46	0.017
	GV	13	1		
Day7	G0	27	1	0	0.001
	GV	38	1		
Day14	G0	33	3	4	0.001
	GV	45	5		
Day28	G0	43	2	32	0.002
	GV	48	3		

*G0: GC without varnish
*GV: GC with varnish applied to surface of specimens

Table 2. Mean± standard deviation of the hardness of Acrosoft tissue conditioner at 5 different time intervals.

group		Mean	Std. Deviation	Mann-Whitney U Statistic	p-Value
Day1	A0*	10	.00	30	0.002
	AV*	12	1		
Day3	A0	25	2.04	30	0.002
	AV	23	1		
Day7	A0	39	2	37	0.005
	AV	36	1		
Day14	A0	51	4	54	0.043
	AV	54	3		
Day28	A0	55	2	58	0.065
	AV	58	4		

*A0: Acrosoft without varnish
*AV: Acrosoft with varnish applied to surface of specimens

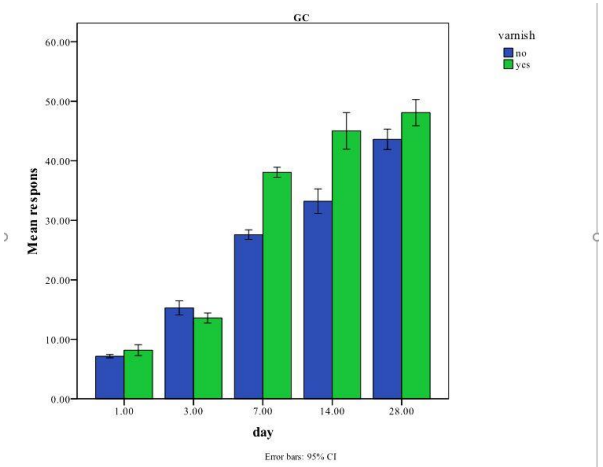

Figure2. The hardness of GC varnish-impregnated and non-varnish-impregnated tissue conditioner containing self-curing resin at 5 different time intervals (1, 3, 7, 14, and 28 days).

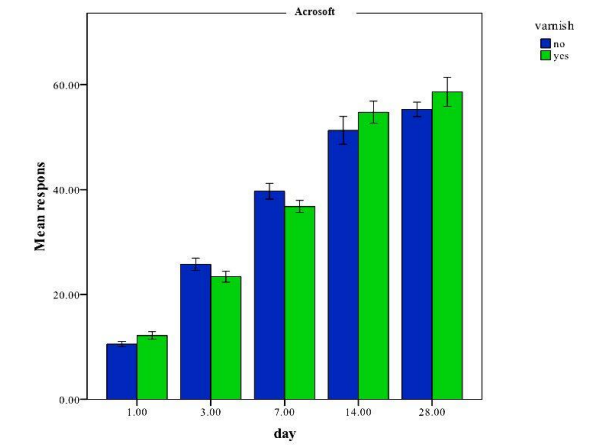

Figure3. The hardness of Acrosoft varnish-impregnated and non-varnish-impregnated tissue conditioner containing self-curing resin at 5 different time intervals (1, 3, 7, 14, and 28 days).

In the paired mean hardness comparison on days 1, 3, 7, 14 and 28 in the GV (Group 1) and G0 (Group 3) groups by Wilcoxon test, a statistically significant difference was observed between all pairs of the groups (p-value <0.009). There was the highest mean hardness difference on consecutive days at days 3 to 7 (12 units in the G0 group, and 24 units in the GV group). A statistically significant difference was observed in the paired mean hardness comparison on days 1, 3, 7, 14 and 28 in the groups of AV (Group 2) and A0 (Group 4) by Wilcoxon test between in all pairs of the groups (p-value <0.013). The highest mean hardness difference on consecutive days was at days 1 to 3 in the A0 (Group 4) group and days 7 to 14 in the AV (Group 2) group.

• Varnish effect comparison:

The comparison of hardness in the GV (Group 1) and G0 (Group 3) groups at each time interval indicated that there was no significant difference between the two groups only on the first day (p-value <0.056) and this difference was statistically significant for the remaining days. Only on day 3, the control group had a higher hardness than the surface coating group. The comparison of the hardness in the AV (Group 2) and A0 (Group 4) groups showed that the difference was statistically significant except for day 28 (p-value = 0.065). This difference was statistically significant for the rest of the days. On days 3 and 7, the hardness in the control group was higher than the surface coating group (Fig 4).

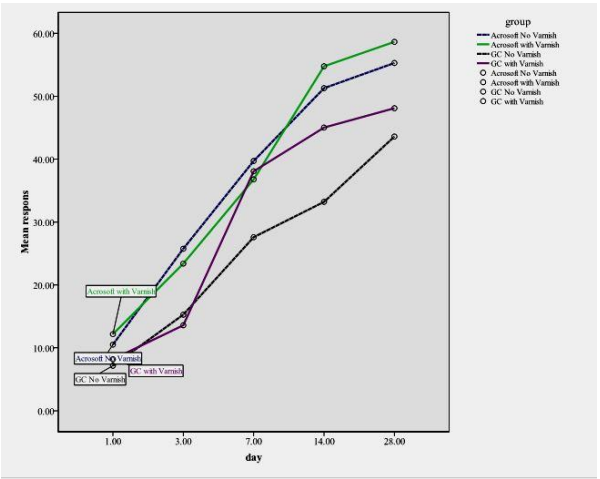

Figure4. Comparison of the hardness of Acrosoft and GC varnish-impregnated tissue conditioner containing self-curing and varnish-free resin at 5 different time intervals (1, 3, 7, 14, and 28 days).

DISCUSSION

Conventional and available tissue conditioners have different clinical applications but are still far from the ideal.[10] The limitations of these materials are the loss of resilience over time and their susceptibility to surface wear. One way to extend the durability of tissue conditioners is to use surface coatings for maintaining surface integrity and softness and reducing the growth of microorganisms in these materials.[4,10]

The present *in vitro* study was conducted on the effect of applying a custom-made varnish (combining 1,1,1-trichloroethane with self-curing acrylic resin) on the hardness of two commercial types of tissue conditioner including Acrosoft and GC over a 28-day period (days 1, 3, 7, 14, 28) after mixing. The results showed that the hardness of all samples (with or without varnish) increased with time. Although in both commercial types of tissue conditioner, the varnished group had a higher hardness than the corresponding control

group on the first day, varnish-coated groups showed less hardness than the control groups on the third day. In the Acrosoft group, even on the seventh day, the varnished group was softer than the control group. However, this trend was reversed in the next few days and the presence of varnish on the specimens made them harder (compared to the control group). In general, an increase in hardness may be associated with the loss of alcohol and/or plasticizer.[11] Ethanol is the main substance released on the first day and its loss is a major factor in increasing hardness.[12,13] It can be stated that on the first day, varnish forms a relatively hard layer on the samples which increases the sample hardness, but partially inhibits the release of alcohol and plasticizer and delays the hardness of tissue conditioner by a few days. After one week, the hardness in the varnished group increased significantly, indicating that the varnish has no effect on the softness of tissue conditioner in the long run.

The finding that varnish makes tissue conditioner harder in the long run (more than 14 days) is consistent with the reports presented by Ebadian[4] who investigated the impact of Monopoly varnish application on the hardness of Acrosoft and Viscogel tissue conditioners. In the study by Ebadian[4], the varnished groups had higher hardness at all-time intervals, whereas in the present study, the varnished samples had less hardness than the control group in the first 3 days. The difference may be due to the differences in the type of surface coating varnish that may affect the rate of alcohol loss and plasticizer or the structure of the material.

Malmstrom[1] investigated the effect of Monopoly and Permaseal coatings on the softness of GC tissue conditioner in the oral environment. His results showed that both types of coatings keep the tissue conditioner soft for more than a month. The difference in results is not unexpected as the study environment and the type of varnish are different and, according to the reports, being *in vivo* or *in vitro* affect the results and the loss of ethanol and plasticizer is not the same in vivo and *in vitro* conditions.[11]

The results also showed that, in general, Acrosoft tissue conditioner was harder than the GC and only on day 7 after mixing, and the mean hardness in the varnished GC group was slightly higher than that in the varnished Acrosoft group. Therefore, the type of tissue conditioner has a significant effect on softness and its maintenance over time. Murata[14] recommended that since materials have a wide range of viscoelastic properties, the appropriate commercial type should be selected according to their clinical application, the intended case, and the expected softness.

According to these studies and the present study, the effect of varnish application on the softness of tissue conditioners is largely dependent on the type of tissue conditioners, the type of varnish, and the time elapsed after mixing. Within the scope of the study, the varnish introduced in this research can soften the tissue conditioner within a 3- to 7-day interval, after which the material hardens more rapidly. Certainly, when the softness of tissue conditioner is of the utmost importance, replacement of the whole material is preferable to varnish application, but this varnish may be useful in the borders of the coating surface of tissue conditioner, where dryness and abrasion are more common. Since applying varnish to the whole tissue conditioner surface extends the service life only for a short time, it is best to apply this varnish on the old soft liner in the border areas to make it softer for a while.

CONCLUSIONS

By the passage of time, the tissue conditioners become progressively harder, but the GC tissue conditioner is still softer than the Acrosoft tissue conditioner. In addition, the application of varnish over 3 days made tissue conditioners softer and in both groups, the varnish made tissue conditioners harder after 7 days.

The varnish containing self-curing resin can be clinically applied in the borders between the soft liner and acrylic denture, which is usually the starting point for debonding. It is available in every dental office and user-friendly. It is cost-effective for the patient by reducing the frequency

of dental visits for soft liner replacements and decreasing the chairside time for the dentist.

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CONFLICTS OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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Original research

EVALUATION OF THE APICAL SEALING ASSOCIATED WITH MAXILLARY FIRST MOLARS RADICULAR MORPHOLOGY USING CONE BEAM COMPUTED TOMOGRAPHY

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ABSTRACT

Objectives: To evaluate the grade of apical sealing associated with the root morphology of maxillary first molars with conventional endo-treatments using cone bean computed tomography (CBCT).

Materials and Methods: The sample included 47 CBCTs. Evaluations were performed independently by one previously trained and calibrated examiner. The grade of apical sealing was evaluated (total sealing, less than 2 mm of sealing, greater than 2 mm unsealed, unsealed and oversealed). Molar angulation according to the palatal plane and the longitudinal axis (vertical, vestibular and palatal), the number of canals, the presence or absence of a second mesiobuccal canal (MB2) and root shape (straight, curved, bayonet, angled, merged, bifurcated) were also assessed. Statistical analysis was performed using the Chi-square test.

Results: There were no differences in apical sealing according to root morphology, shape and molar root inclination ($p>0.05$). A significant association was reported between the presence of MB2 and a buccal inclination of the maxillary first molar ($p = 0.048$).

Conclusions: Root morphology and molar angulation did not affect the apical sealing of maxillary first molars. However, the presence of the MB2 was associated with a buccal inclination of the maxillary first molar.

Keywords: Cone-beam CT, root canal obturation, molar, dental pulp cavity.

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INTRODUCTION

Endodontic treatment success can be evaluated clinically and radiographically and by the remission of pathological processes.[1] The persistence of symptoms is often due to different causes such as the presence of non-located canals, or incompletely sealed canals, anatomical variations that determine a complicated morphology of root canals, or the presence of supplementary canals.[2] Adequate knowledge of root morphology is the main factor of success of conventional endodontic treatment. Baratto *et al.*[3] reported that first upper molars present three or four canals. With the use of cone beam computed tomography (CBCT), Pécora *et al.*[4] analysed the internal anatomy of maxillary first molars, reporting a frequency of 37% of four canals.

Many factors can affect the endodontic treatment success[5], the most crucial apical sealing.[6] Correct apical sealing is based on adequate root canal obturation to prevent the recurrence of bacterial infection.[7] Microleakage between the root canal and periapical tissues is hindered leading to death of any surviving microorganisms.[8] This should ensure optimal sealing in all dimensions blocking apical or lateral communication with the periodontium. Incomplete or nonexistent filling of a root canal by ignoring its presence is the main causes of endodontic treatment failure.[9]

Endodontic treatment success requires knowledge of the anatomy and morphology of the dental canalicular system, and clinicians must be prepared to identify all teeth showing an unusual anatomical configuration.[10] One aspect of canal configuration that has shown to have an important impact on instrumentation is canal curvature. The amount of curvature of a root canal affects access for instrumentation and also the risk of instrument separation. It is in this context that the high sensitivity and specificity of CBCT allows identification of the presence of additional canals, especially the second mesiobuccal canal (MB2) frequently present in maxillary first molars.[3,11]

The aim of this study was to evaluate the condition of apical sealing in relation to the root morphology of maxillary first molars with conventional endo-treatments using CBCT.

MATERIALS AND METHODS

The study was approved by the Ethics Committee of the Universidad Científica del Sur (Approval No. 000261). The material was selected from a series of records from a private Dental Imaging Center (CDI Diagnostic Imaging Center, Lima, Peru) between January 2018 and December 2019. The study population was composed of 47 CBCTs scans (32 women and 15 men) in which the condition of apical sealing in relation to root morphology (root divergence, root shape, root width, number of canals) were evaluated. The sample size was calculated using the Open Epi statistical software http://openepi.com/SampleSize/SSPropor.htm, automatically generated with a population size of 100, confidence level of 95%, frequency of outcome factor in the population of 25%, confidence limits d = 10%. We obtained a sample size of 43, however we obtained 47 CBCTs with endodontic treatment in the upper first molar. In addition, sex, molar angulation (vertical, vestibular, palatine) and the presence or absence of the MB2 canal were evaluated.

Inclusion criteria comprised CBCTs presenting conventional endo-treatments, excluding CBCTs of patients with radicular fractures, excessive destruction of tooth structure, pathological processes and CBCT images distorted by patient movement.

CBCT Data acquisition

All tomographic images were taken using a Picasso Master 3D, (Vatech Hwaseong, South Korea), with 8mA and 90 Kv. The field of view (FOV) was 20 x 19 cm and the voxel size was 0.4 mm with an exposure time of 20 seconds. The patient was positioned correctly with the teeth in maximum intercuspation. Digital Imaging and Communications in Medicine (DICOM) images were examined with a 3D imaging software (3D Viewer, EzImplant, version 1.5.8265.1, South Korea). Images were viewed in a dimly lit room on an 14-inch laptop screen (AMD E -300 APU Radeon ™, Lenovo, China) set at a screen resolution of 1366 × 768 pixels.

Measurements

Evaluation of apical sealing was performed using sagittal and coronal reconstruction for the mesial, distal and palatal root and considering five categories: complete sealing, sealed less than 2

mm; unsealed greater than 2 mm; unsealed and overfilled root canal treatment in relation to the apical foramen (Figure 1).

Figure 1. Linear measurement of apical sealing from the top of the endodontic material to the limit of the apex.

Molar inclination (vertical, vestibular and palatal) was evaluated by a coronal tomographic slice. This view allowed determining the direction drawing a line on the horizontal planes of the palatine bones with the apex toward the longitudinal axis of the tooth (Figure 2).

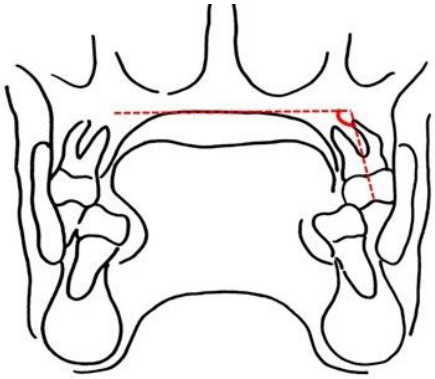

Figure 2. Coronal view of the measurement of the angle between the longitudinal axis of the tooth and the palatal plane.

The number of canals was determined in successive axial sections in the anoccluso-apical direction (Figure 3).

Figure 3. Axial view showing the presence of three canals at the cemento-enamel junction level. One of the canals has no endodontic treatment and the other two are completely sealed.

This allowed visualization of the MB2 (present/absent) (Figure 4).

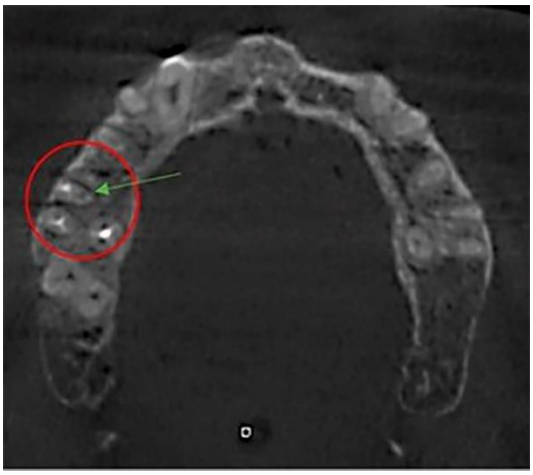

Figure 4. Axial view showing the presence of the MB2 without proper sealing at the cemento-enamel junction level.

The shape of the root structure was examined (straight, curved, bayonet, angled, merged and bifurcated). The mesial and distal root was assessed in the sagittal view. The palatal root was determined in a coronal section. All the evaluations were performed taking into account the longitudinal axis of the maxillary first molar.

Calibration

The intra-examiner calibration phase was analysed using the intra-class correlation coefficient (ICC) for quantitative variables (> 0.9). For qualitative variables such as apical sealing and molar inclination, the Kappa statistical test was used (0.722 –1). All measurements were performed over a two-week interval. A pilot study was performed to calculate the sample size using 15 CBCTs to evaluate the condition of the apical sealing of maxillary first molars and to determine root morphology, molar angulation and the presence or absence of MB2.

Statistical analysis

The statistical analyses were performed using SPSS for Windows (version 22.0; SPSS, Chicago III). Normality was evaluated by the Shapiro Wilk test. Two groups presented normality and the Student's t-test was used. When normality was not obtained for the other groups, the Mann Whitney U-test was used. When more than 3 groups obtained normality the ANOVA test was selected and non-parametric groups were analysed using the Kruskal-Wallis test. Associations were determined

with the Chi-square test. P <0.05 was considered to indicate statistical significance.

RESULTS

Apical sealing according to root morphology did not show any statistically significant differences (p>0.05). In most cases the apical sealing was found to be > 2 mm. The presence of MB2 versus root shape is described in Table 1.

Table 1. Association between the presence of the MB2 canal and shape of the mesial root

Root shape	Presence of MB2		Total n (%)
	Presence n (%)	Absence n (%)	
Straight	0 (0.0)	9 (100)	9 (100)
Curve	3 (7.9)	35 (92.1)	38 (100)
Total			47 (100)

Chi-square test p=0.384

Root morphology was straight in the group in which the MB2 was absent (100%). Furthermore, the performance of apical sealing associated with molar inclination is described in Table 2 showing that palatal molar inclination of the mesiobuccal and distobuccal canal was observed in 55.6% of the group sub-obturated > 2 mm.

Table 2. Association between sealed apical canal and maxillary first molar angulation

Canal	Molar angulation	Measurement	Complete sealing	Sealed < 2mm	Unsealed >2mm	Unsealed	Overfilled	Total	p
Mesiobuccal canal	Vertical	n	7	6	15	1	0	29	0.913 †
		%	24.1	20.7	51.7	3.4	0	100	
	Buccal	n	2	3	4	0	0	9	
		%	22.2	33.3	44.4	0	0	100	
	Palatal	n	3	1	5	0	0	9	
		%	33.3	11.1	55.6	0	0	100	
Distobuccal canal	Vertical	n	8	9	9	3	0	29	0.692 †
		%	27.6	31	10.3	0	0	100	
	Buccal	n	2	1	4	2	0	9	
		%	22.2	11.1	44.4	22.2	0	100	
	Palatal	n	1	2	5	1	0	9	
		%	11.1	22.2	55.6	11.1	0	100	
Patalal canal	Vertical	n	8	7	11	2	1	29	0.950 †
		%	27.6	24.1	37.9	6.9	3.4	100	
	Buccal	n	2	3	3	1	0	9	
		%	22.2	33.3	33.3	11.1	0	100	
	Palatal	n	4	2	3	0	0	9	
		%	44.4	22.2	33.3	0	0	100	

† Chi-square test

Total sealing of the palatal canal was obtained in 44.4%. The chi-square test showed no significant values in these associations (p>0.05). However, the presence of the MB2 showed a statistically significant association with maxillary first molar inclination (p = 0.048) between the presence of the MB2 and a vestibular molar inclination in 22.2% of the cases. The MB2 was absent in 77.8 % of the vestibular inclined molars (Table 3).

Table 3. Association between the presence of the MB2 canal and maxillary first molar inclination.

Molar Inclination	**Presence of MB2**		**Total n (%)**
	Presence n (%)	**Absence n (%)**	
Vertical	0 (0.0)	29 (100)	29 (100)
Buccal	2 (22.2)	7 (77.8)	9 (100)
Palatal	1 (11.1)	8 (88.9)	9 (100)
			47 (100)

Chi-square test p=0.048

DISCUSSION

The success of endodontic treatment is dependent on hermetically cleaning, shaping and filling the root canal system and achieving an adequate coronal seal.[12-13] Therefore, the technical quality of the root filling is an important factor in treatment success.[14] Root canal morphology evaluation is difficult, considering that the apical root canal is often conical, with multiple parallel walls or narrowing of apical sites.[15] This is why the use of CBCT is gaining importance in the diagnosis of root canal morphology. Intra- observer calibration was conducted over a period of two weeks, using kappa statistical analysis for each qualitative variable, and ICC for quantitative variables. Both methods obtained good results ensuring the reliability of the study.

This study evaluated morphological variation in order to determine associations between morphology and apical sealing. Although total sealing of the duct is ideal, it is common to find sealing less than 2 mm. While this sealing is allowed and guarantees the success of the treatment, the presence of unsealed ducts, sealing > 2 mm or oversealing results in ineffective treatment. Most of the cases in our sample presented an unsealed canal or an overfilled root canal treatment, leading to a high risk of endodontic treatment failure because bacteria can colonize the root canal. On radiographic examination, good root filling should ideally follow the continuous taper form of the prepared root canal from the coronal aspect to the apex, have no voids between the root filling and canal walls and have an optimal distance of 0.5 to 2 mm from the radiographic apex.[16] However, there is much discussion about the exact ending point of root canal treatment. Incomplete detection of all the root canals leading to untreated canals has been reported as a major cause of failure in root canal therapy. [17] According to Sjogren *et al*.[18] the apical sealing limit of root canals is more critical than the technique or sealant used. When the obturation reached 0 to 2 mm from the radiographic apex, 94% of clinical success was achieved while when the dimension was greater than 2 mm, the success this rate was reduced to 68% and 76% when the canal was overfilled. In addition, the success rate for retreatment therapy of properly sealed canals was 67%, whereas for deficient root canal sealing the percentage decreased to 31%. These findings reinforce the importance of correct apical endodontic sealing.

Other clinical studies have been conducted using magnification equipment, such as magnifying loupes and microscopes, and describing the presence of the MB2 canal in the maxillary first molar.[19] Although this is useful for locating the MB2 canal, magnication systems present limitations, such as a limited view, showing only the entrance foramen of the MB2 canal. In cases of inclined or rotated molars, magnification becomes less effective, since a severe to moderate angulation of the tooth prevents a good view of the cavity floor. Finally, equipment costs and operator training are important factors that limit the use of magnification. These limitations are currently overcome through the use of CBCT, a simple

diagnostic technique.

In relation to the MB2 and our findings, the literature reports a variety of information. Cleghorn *et al.*[20] reported that the incidence of two canals in the mesiobuccal root was 56.8%, being 43.1% for one canal, among the studies reviewed. Abuabara *et al.*[21] found a similar result reporting 62% of MB2. Another study that identified two MB2 in 48.2% of the maxillary first molars was performed in an Indian population.[22] Two similar studies conducted in Chinese populations detected MB2 canals in 52% of the teeth.[23,24] Other authors have compared the ability of CBCT to detect MB2 canals with clinical sectioning and reported no statistically significant differences.[25,26]

Shenoi *et al.*[27] analysed MB2 configuration by CBCT, reporting 80% of MB2 identification, of which 54.16 % were in the coronal third, 29.16% in the middle third and 16.66% were in the apical third. A significant association was found in our study between the presence of the MB2 and the buccal inclination of the maxillary first molar, while no other study has reported these results. This is a clinically important morphological finding that should be further investigated in larger samples in other types of populations.

CONCLUSIONS

Root morphology and molar inclination do not affect the apical sealing of maxillary first molars. However, we found that the presence of the MB2 was associated with the buccal inclination of the maxillary first molar.

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None.

CONFLICTS OF INTEREST STATEMENT

None.

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Original research

THE EFFECTS OF UNCONTROLLED EXTRACTIONS OF THE PERMANENT LOWER FIRST MOLARS ON THE PROGNOSIS OF SPONTANEOUS SPACE CLOSURE AND OCCLUSION

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Mustafa Aydınbelge[2]
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ABSTRACT

Objectives: This cross-sectional study aimed to evaluate the prognosis of spontaneous space closure and occlusion in uncontrolled permanent lower first molar extractions in patients with different developmental stages.

Materials and Methods: Fifty permanent lower first molar extractions were included in the study. Extractions were divided into two groups as appropriate-timing (Group 1- 6th or 7th stages of Nolla) and late-timing (Group 2- 8th or 9th stages of Nolla), according to the Nolla calcification stage of permanent second molar germs in the same quadrant. In the 24th month, based on clinical/radiological/ photographic data, the success of spontaneous space closure, rotation degrees of adjacent teeth, and dental midline deviations were evaluated.

Results: Successful spontaneous space closure was observed in 52% in Group 1, and no successful result was present in Group 2. The difference was statistically significant ($p<0.001$). Rotation results of adjacent teeth were determined more frequently in Group 2, and the difference was not statistically significant ($p=0.138$, $p=0.084$, $p=0.120$). Dental midline deviations were statistically significantly higher in unilateral extractions compared to bilateral extractions ($p=0.006$).

Conclusions: The timing of permanent lower first molar extractions for successful spontaneous space closure should be planned at the sixth or seventh development stage of the permanent lower second molar, according to Nolla's classification. Since rotations in adjacent teeth occur regardless of extraction timing, cases should be followed-up and intervened if necessary. Besides, unilateral permanent first molar tooth extractions should be avoided as much as possible since they cause dental midline deviation.

Key Words: Dental occlusion, malocclusion, tooth extraction.

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INTRODUCTION

Maintenance of permanent first molar teeth in the mouth functionally is essential because of their critical role in the development of occlusion and mastication.[1] However, dental caries is one of the most common diseases around the world[2], and since the permanent first molars are the most affected by caries and hypomineralization, extraction may be necessary due to excessive loss of crown structure and extensive periradicular infections during different dentition periods.[3]

As a result of the extraction of permanent first molar teeth in proper time, it is stated that permanent second molars will take a proper position by mesialization to the extraction space. The appropriate extraction time for obtaining an acceptable and ideal dental occlusion is the period between the completion of crown formation and the development of one-third of the root structure of permanent second molars.[4-7] This stage coincides with the period between "6 or 7" according to the Nolla classification and "E" according to the Demirjian classification.[8-11] In the classifications of Demirjian and Nolla, the developmental stages of the teeth can be determined based on the level of calcification.[8,9,12] Also, it is recommended that the mineralization in furcation of the second permanent molars should be detected radiographically.[3,4]

The spongious structure of the upper jaw and the distal eruption direction of the permanent second molars increase the possibility of parallel movement of these teeth. Therefore, the early and late extractions in the upper jaw usually result in successful spontaneous space closure. However, if extractions are performed in the early period, there may be a residual space (5-10 mm.) between the permanent second molars and the second premolars. It is also reported that in case of late extraction, tipping of the permanent second molars and mesiopalatal rotation around the palatal root may be observed.[13]

Due to the compact structure of the lower jaw that allows more complex tooth movements and the mesial eruption direction of the permanent second molars, the tipping of these teeth may be seen during the mesial movement. Therefore, early and late extractions cause more complicated results in the lower jaw.[5,14] In early extractions, if the primary second molar is also lost early, the second premolars show distal movement, distal tipping, or rotational movements in the eruption phase.[10] In late extractions in the lower jaw, crossbite, occlusal disharmony in the non-working side, and distal tipping of the second premolar may be observed as a result of mesiolingual tipping of the permanent second molar tooth. Besides, it is reported that inappropriate contact relationships can cause periodontal diseases and atrophy of the alveolar bone.[13]

Although the possible results of uncontrolled extractions of the permanent first molars have been described, there are no evidence-based clinical studies in the literature. This cross-sectional study aims to evaluate the prognosis of extraction space, spontaneous space closure, rotation of the adjacent teeth, and dental midline deviations in unilateral/bilateral extractions of lower permanent first molars in two different developmental stages.

MATERIALS AND METHODS

Ethical Approval

The study protocol was approved by the Ethics Committee of Erciyes University, Faculty of Medicine (approval ID: 2020/39-decision date: 15/01/2020). All procedures of the presented research were completed based on the Declaration of Helsinki. Also, the written informed consent forms were signed by the parents and patients.

Study Design

The present cross-sectional research was conducted on patients who had presented to the Pediatric Dentistry Clinics of Erciyes University or Ankara University between 2012 and 2016 with the indication of unilateral or bilateral permanent lower first molar extraction. The main extraction indications were as follows: i) non-restorable extensive dental caries, ii) developmental dental anomalies/defects (hypomineralization, defects of enamel or dentin), iii) excessive periradicular/ perifurcal lesions. In this study, preoperative intraoral photographs and panoramic radiographs, together with postoperative (on 24±2nd month) clinical examination findings and intraoral photographs, were used for assessment of

spontaneous space closure, rotation degree of adjacent teeth, and midline deviations.

Inclusion Criteria

Considering the medical and dental history, photographic records, and panoramic radiographic examinations; inclusion criteria were as follows:

- Patients without dental anomalies
- Cases with at least one lower permanent first molar tooth extraction
- Patients with preoperative and postoperative (on 24±2nd month) panoramic radiographs and intraoral photographs
- Angle Class I cases (diagnosed with panoramic radiographs and intraoral photographs)
- Patients without skeletal or dental bite anomalies
- Patients without severe anterior crowding

According to the inclusion criteria, 50 teeth (in 39 patients) were found to be appropriate for research design and included in the study.

Inter-Examiner Reliability

Determination of the study groups and evaluation of the results were performed by two different examiners. The agreement between the examiners was determined by using Cohen's Kappa Test, and values 0.8 or above demonstrated good reliability. In this study, the mean k value was 0.90.

Determination of the Study Groups

The cases included in the present study were divided into two groups by using radiographic data according to Nolla's development stage of the permanent lower second molar germs on the side of extraction. Group 1 referred to the ideal period (appropriate timing) for the extraction of permanent first molars, whereas Group 2 referred to the late period.

Group 1

Group 1 included 25 teeth (in ten female and ten male patients) at Nolla stages[8] 6 (7 teeth) or 7 (18 teeth). The average age was determined as 8.6 (7 to 11) years.

Group 2

Group 2 included 25 teeth (8 females and 11 males) at Nolla stages[8] 8 (12 teeth) or 9 (13 teeth). The average age was determined as 11.7 (11 to 13) years.

Evaluation Criteria

1. Evaluation of Spontaneous Space Closure

The success of spontaneous space closure was evaluated by clinical radiographical examination for Groups 1 and 2 included in the study at 24th-month control. In clinical examination, the residual extraction space was recorded by measuring the distance between the distal surface of the anterior tooth and the mesial surface of the posterior tooth using a digital caliper. It was considered as "successful" when appropriate contact relations were obtained between the permanent second molars and the second premolars, together with the absence of severe rotation results in adjacent teeth. The "unsuccessful" conditions regarding space closure were as follows:

Condition 1:

A: Inappropriate space closure due to overeruption of the upper permanent first molar and consequent tipping of the lower second premolar (5 to 10 mm. of space between the permanent second molar and the second premolar).

B: Inappropriate space closure due to tipping of the permanent second molar or the second premolar (5 to 10 mm. of space between the permanent second molar and the second premolar).

Condition 2:

A: Inappropriate space closure due to overeruption of the upper permanent first molar and consequent tipping of the lower second premolar (<5 mm. of space between the permanent second molar and the second premolar).

B: Inappropriate space closure due to tipping of the permanent second molar or the second premolar (<5 mm. of space between the permanent second molar and the second premolar).

Condition 3:

Condition 3 includes the appropriate contact relation between the permanent second molar and the second premolar as a result of the distalization of the second premolar. However, this condition showed that inappropriate space closure with

residual extraction space occurred between the first and second premolars.

It was evaluated whether there was a statistically significant difference between Group 1 and Group 2 regarding space closure success.

2. Evaluation of Rotations

Rotations in permanent second molar and second premolar teeth were evaluated by clinical examination and intraoral photographs based on the tooth position on the alveolar crest for each study group (Groups 1 and 2). On intraoral photographs, the angle between the line passing through the buccolingual direction of the tooth and the alveolar crest direction was considered as the rotation angle. Rotation angles <45° were defined as mild, and those >45° were defined as severe. It was evaluated whether there was a statistically significant difference between Group 1 and Group 2 regarding rotation results.

3. Evaluation of Dental Midline Deviations

In the evaluation of dental midline deviation, all cases in this study were divided into two groups according to the extractions being unilateral (n=34) or bilateral (n=8) regardless of developmental stages of the permanent second molars. Dental midline deviations due to the distalization of canines and incisors were determined by clinical examination findings. It was evaluated whether there was a statistically significant difference between unilateral and bilateral extraction groups for dental midline deviation.

Statistical Analysis

Statistical analysis of the results was performed by using SPSS 11.5 Software-Windows version. Number (percentage) was used for descriptive qualitative variables. When the relation between two qualitative variables was analyzed, Chi-Square and Fisher-Exact tests were used. The statistical significance level was determined as 5%.

RESULTS

Results of Spontaneous Space Closure:

The success rates of spontaneous space closure in Group 1 (Nolla Stage 6 or 7) was 52% (Table 1, Figure 1).

Table 1. The results of spontaneous space closure for each group and the statistical comparison between Group 1 and 2

Variables			Groups				p-value
			Group 1		Group 2		
			n	%	n	%	
Space Closure	Successful		13	52.0	0	0.0	<0.001*
	Unsuccessful	Condition 1 (1A+1B)	6	24.0	11	44.0	
		Condition 2 (2A+2B)	4	16.0	14	56.0	
		Condition 3	2	8.0	0	0.0	

(* indicates statistical significance, Fisher-Exact test)

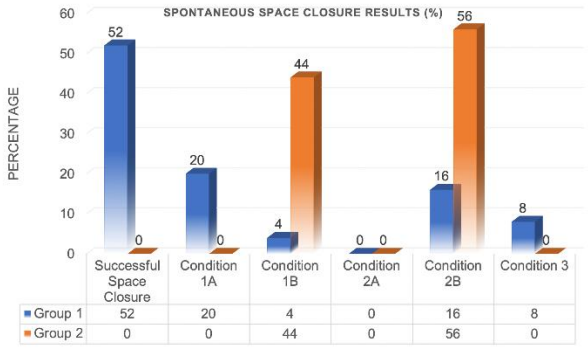

Figure 1: The distribution (percentage-%) of the results of space closure.

In the evaluation for spontaneous space closure of the cases in Group 1:

- Space closure was considered as successful in 13 teeth (52%) (Figure 2).

Figure 2: Panoramic radiographic image of the right and left lower permanent first molars which required extraction in a case in Group 1 (a). Radiographic (b) and intraoral (c) images at the 24-month follow-up of a case that was considered successful because of the mesialization of the permanent lower second molar to the extraction space and appropriate contact relations (b).

- Inappropriate space closure was observed due to the overeruption of upper permanent first molar in five teeth (20%) (Condition 1A) (Figure 3).

Figure 3: Panoramic radiographic image of the left permanent lower first molar tooth that required extraction in a case in Group 1 (a). Radiographic (b) and intraoral (c) images at the 24-month follow-up of a case with inappropriate space closure that was considered unsuccessful due to overeruption of the upper permanent first molar (Condition 1A).

- 8 mm. of residual space between the permanent lower second molar and second premolar was observed in one tooth (4%) due to the tipping of the lower permanent second molar (Condition 1B).

- <5 mm. of residual space between the permanent lower second molar and second premolar was observed in four teeth (16%) due to tipping of the lower permanent second molar (Condition 2B).

- Inappropriate space closure was observed in two teeth (8%) due to the distalization of the second premolar (Condition 3) (Figure 4).

Figure 4: Panoramic radiographic image of the right permanent lower first molar tooth, which required extraction in a case in Group 1 (a). Radiographic (b) and intraoral (c) images at the 24-month follow-up of a case with inappropriate space closure that was considered unsuccessful due to the distalization of the lower second premolar (Condition 3).

All of the cases in Group 2 (Nolla Stage 8 or 9) (n = 25) were found to be unsuccessful regarding space closure (Table 1, Figure 1).

In the evaluation for space closure of the cases in Group 2:

- 5-10 mm. of residual space between the permanent lower second molar and second premolar was observed in 11 teeth (44%) due to tipping of the permanent lower second molar (Condition 1B) (Figure 5).

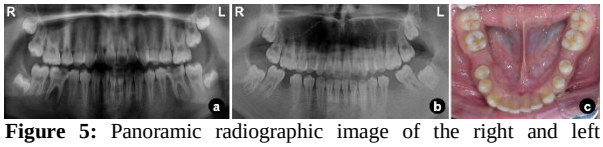

Figure 5: Panoramic radiographic image of the right and left permanent lower first molar teeth, which required extraction in a case in Group 2 (a). Radiographic (b) and intraoral (c) images at the 24-month follow-up of a case that was considered unsuccessful with residual spaces between the permanent lower second molar and second premolar [Right <5 mm. (Condition 2B), left: 5-10 mm. (Condition 1B)] due to the tipping of the lower second premolar.

- <5 mm. of residual space between the permanent lower second molar and second premolar was observed in 14 teeth (56%) due to tipping of the lower permanent second molar (Condition 2B) (Figure 5).

Statistical analysis of two groups regarding success in achieving space closure revealed that differences between the groups were statistically significant ($p<0.001$) (Table 1).

Results of Rotation of Adjacent Teeth:

In the evaluation for rotation of the adjacent teeth in Group 1 (Table 2, Figure 6):

Table 2. Results of rotation of the adjacent teeth in each group and the statistical comparison between Group 1 and 2 (a: Chi-Square test, b: Fisher-Exact test)

Variables		Groups				p-value
		Group 1		Group 2		
		n	%	n	%	
Rotation results of permanent second molars	**Absent**	7	28.0	2	8.0	0.138[b]
	Mild	18	72.0	23	92.0	
	Severe	0	0.0	0	0.0	
Rotation results of second premolars	**Absent**	12	48.0	7	28.0	0.084[a]
	Mild	11	44.0	10	40.0	
	Severe	2	8.0	8	32.0	
Rotation results of first premolars	**Absent**	16	64.0	9	36.0	0.120[b]
	Mild	8	32.0	14	56.0	
	Severe	1	4.0	2	8.0	

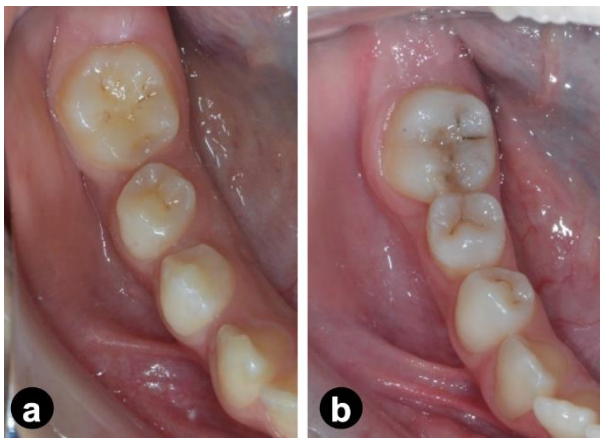

Figure 6: Intraoral images of mild rotation (Group 1) (a) of the permanent second molar and severe rotation (Group 2) (b) of the second premolar.

• There was no rotation in seven permanent lower second molars (28%), whereas mild rotation was observed in 18 teeth (72%).

• There was no rotation in 12 lower second premolars (48%). A mild rotation was observed in 11 lower second premolars (44%), whereas severe rotations were observed in two of the second premolars (8%).

• There was no rotation in 16 lower first premolars (64%). A mild rotation was observed in eight lower first premolars (32%), and a severe rotation was observed in one first premolar (4%).

In the evaluation for rotation of the adjacent teeth in Group 2 (Table 2, Figure 6):

• There was no rotation in two lower permanent second molars (8%), whereas a mild rotation was observed in 23 teeth (92%).

• There was no rotation in seven lower second premolars (28%). A mild rotation was observed in ten lower second premolars (40%), whereas eight of the second premolars had severe rotations (32%).

• There was no rotation in nine lower first premolars (36%). A mild rotation was observed in 14 lower first premolars (56%), whereas two of the first premolars had severe rotations (8%).

In statistical analysis, there was no statistically significant difference between the groups regarding the rotation of the adjacent teeth (Table 2).

Results of Dental Midline Deviation:

In the evaluation for midline deviation, midline deviation was observed in 27 cases in unilateral extractions (79.4%) and two cases in bilateral extractions (25%). The difference between unilateral and bilateral extractions was found to be statistically significant (p=0.006) (Table 3, Figure 7).

Table 3. Midline deviation results and the statistical comparison between unilateral and bilateral extractions (* indicates statistical significance, Fisher-Exact test)

Variables	Dental Midline Deviation				
	Presence		Absence		p-value
	n	%	n	%	
Unilateral Extractions	27	79.4	7	20.6	**0.006***
Bilateral Extractions	2	25.0	6	75.0	

Figure 7: Intraoral image of dental midline deviation in a case with unilateral extraction.

DISCUSSION

Studies evaluating the prognosis of spontaneous space closure of the permanent first molars have reported that extractions in the upper jaw mostly achieved an acceptable occlusion.[6,10,11,15-17] However, in the lower jaw, due to the biological structure of bone tissue and the eruption direction of the permanent second molars, the results of early and late permanent first molar extractions may become more complicated.[5,14] Therefore, the present study aimed to investigate the effect of lower first molar tooth extractions on the prognosis of occlusion in two different dental developmental stages.

The molar occlusion relation should be Angle Class I in order to obtain an acceptable and ideal occlusion while deciding on the extraction of the permanent first molar teeth. Lower first molar tooth extractions should be avoided as much as possible in Angle Class II, Division II cases, whereas upper first molar tooth extractions in Angle Class III. However, if a tooth extraction is required due to dental necessities, it should be consulted with Orthodontics not to exacerbate the malocclusion.[18-21] In a study by Teo *et al.*[10], even though the study included patients in Angle Class I, II, and III in contrast to the present study, the authors reported that space closure success rates were higher in Angle Class I patients compared to the other groups. For this reason, cases with Angle Class I molar relationship were included in the present study.

It has been stated that the appropriate extraction time was the calcification period of bifurcation area of the permanent second molars to achieve successful spontaneous space closure after extraction of the permanent first molar teeth.[5,7,8] This timing is equal to the sixth and seventh stages of Nolla classification. As a result of performing extractions later than these stages, tipping, displacement, overeruption, and occlusal abnormalities develop in the adjacent teeth. For this reason, in our study, two study groups were included as appropriate (Nolla stage 6 or 7) and late (Nolla stages 8 or 9) extractions.

The patients were evaluated regarding space closure at the 24-month follow-up examination. Space closure was found to be successful in 13 cases (52%) in Group 1, which included the cases with the permanent second molars at the 6th or 7th stage according to the Nolla classification. However, there was no successful result in Group 2, which included the permanent second molars at the eighth or ninth stages of Nolla classification, and this difference was statistically significant ($p<0.001$). In related studies, success rates similar to our study were reported for space closure. Teo *et al.*[10] reported the success of space closure as 66% in lower first molar extraction at the ideal developmental stage (Demirjian's stage E) of the permanent second molar.

Similarly, Patel *et al.*[11] stated that 49% of 153 permanent first molar extractions in the lower arch had successful space closure. However, Teo *et al.*[10] and Patel *et al.*[11] concluded that the dental age or the developmental stage of the permanent second molars had no significant effect on the success of space closure in the lower dental arch. The authors stated that successful space closure was achieved in the early and late developmental periods. In this regard, we thought that the authors' reporting of successful space closure in the out-of-ideal developmental stage might have been related to using Demirjian's classification. However, Jälevik and Möller[16] reported the success rate of space closure as 66% after the upper and lower permanent first molar extractions. The authors emphasized that optimal spontaneous space closure could be observed when first molars were extracted prior to the eruption of the second molar teeth.[16]

Condition 1A, which indicates unsuccessful space closure due to overeruption of the upper permanent first molar tooth, was observed in five cases (20%) in Group 1 and not in Group 2. Therefore, it is possible to say that overeruption is more likely to occur in the early mixed-dentition period., "Compensation Extractions," which expresses controlled extraction of the upper permanent first molars, was recommended to avoid such a failure caused by overeruption of the upper first molar tooth. However, to perform these extractions, various requirements should be provided. The cases should be in the period of mixed-dentition, not include congenital tooth agenesis, involve an Angle Class I molar relationship, and also, overjet and overbite should be within normal limits.[3,13] There is no evidence-based clinical study evaluating compensation extractions of the permanent first molars. However, in a study[15] evaluating the necessity of controlled extractions, the authors stated that compensation extractions were required in 17% of cases.

Condition 1B, which indicates unsuccess in space closure (5-10 mm. of residual space) due to tipping of the lower permanent second molar tooth to the extraction space, was observed in one case in Group 1 (4%) and 11 cases in Group 2 (44%).

Condition 2B, which indicates unsuccess in space closure (<5 mm. of residual space) due to tipping of the adjacent teeth to the extraction space, was observed in 4 cases (16%) in Group 1 and 14 cases (56%) in Group 2. It is also known that late extractions increase the probability of failure and may cause complications such as tipping of the adjacent teeth, inappropriate space closure, masticatory problems, periodontal diseases, and temporomandibular diseases (TMD).[3,10,13] As a result of the present study, while occlusal problems occurred in the cases belonging to Group 2, periodontal diseases and TMD, which require a more extended process duration to occur, were not encountered. However, it may be possible to observe these pathologies if the extraction cases are followed-up for more extended periods. Therefore, it is suggested that it will be more suitable to make a further evaluation. Concerning Condition 3, which indicates space closure by distalization of the second premolar, was observed in two cases (8%) in Group 1; however, it was not detected in Group 2. Jälevik and Möller[16] stated that distalization occurred in the second premolar tooth in three cases (%10), and the germs of all these teeth were inclined distally in the alveolar bone, similar to our study. In cases with an eruption in the distal direction of the second premolar teeth, it is possible to say that it would be beneficial to monitor at regular intervals and perform necessary treatment procedures.

In our study, the cases were evaluated in terms of rotations of adjacent teeth at the 24-month examination, and mild rotation was observed in 18 (72%) permanent second molar teeth in Group 1 and 23 (92%) teeth in Group 2. A statistically significant difference was not present between the two groups (p=0.138). Similarly, rotation results were detected in the first and second premolars, and no statistically significant difference was present between Groups 1 and 2 (p=0.120 for the first premolars, p=0.084 for the second premolars). Teo *et al.*[10] reported that rotations could be observed in permanent second molars or second premolars, even when permanent first molars had been extracted at the ideal root developmental stage of the permanent second molars in the lower jaw. Additionally, since the rotation occurring in adjacent teeth is independent of the timing of extraction, all extraction cases should be monitored at regular intervals, and all precautions should be taken. Also, the required interventions should be performed in an early period if the rotation result occurs.

In terms of midline deviation, the extraction cases were divided into two groups according to the extractions being unilateral or bilateral, and the difference was analyzed statistically. The midline deviation was detected in 27 cases (79.4%) in unilateral extractions and two cases (25%) in bilateral extraction cases; this difference was statistically significant (p=0.006). Unilateral extractions of permanent first molar teeth in the same dental arch during the growth and development period cause skeletal asymmetries in the lower facial third, together with a dental midline deviation in the long term.[22] Çağlaroğlu *et al.*[22] reported that unilateral extractions of permanent first molars in the lower and upper jaw caused dental midline deviation; however, this was more prominent in the lower jaw. The authors also concluded that the dental midline significantly shifted towards the side of extraction in the lower and upper jaws.[22] In order to avoid complications caused by unilateral extractions, "Balance Extractions" is recommended, which involves controlled extraction of the contralateral permanent first molar tooth. However, this approach has requirements similar to compensation extractions.[3,13] The cases should not have congenital tooth agenesis, be in the mixed-dentition period, present an Angle Class I molar relationship, and overjet/overbite should be within normal limits.

Additionally, mild crowding in the anterior or buccal segment may be acceptable. However, there is a lack of information about the amount of this crowding.[3,13] Albadri *et al.*[15] stated that compensation extractions were required in 17% of cases in their study. The cases that do not fulfill these requirements should be followed up at regular intervals and consulted with the orthodontic department if necessary.

CONCLUSIONS

It is recommended for successful space closure that the permanent lower first molar extractions should be performed during the sixth or seventh developmental stage of permanent second molars in Nolla's classification. Rotations observed in adjacent teeth, especially in permanent lower second molars, develop regardless of the extraction timing, and therefore, patients should be followed-up at regular intervals and intervened in the early period if necessary. Further evidence-based and prospective clinical trials are needed regarding controlled extractions of permanent lower first molars.

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CONFLICTS OF INTEREST STATEMENT

None.

Daimi Alt Birinci Azı Dişlerinin Kontrolsüz Çekimlerinin Spontan Boşluk Kapanması ve Oklüzyon Prognozuna Etkileri

ÖZ

Amaç: *Bu kesitsel çalışmanın amacı, farklı gelişim evrelerinde olan hastalarda, daimi alt birinci azı dişlerinin kontrolsüz çekimlerinde spontan boşluk kapanması ve oklüzyonunun prognozunu değerlendirmektir.* ***Gereç ve Yöntemler:*** *50 daimi alt birinci azı diş çekimi çalışmaya dahil edilmiştir. Çekimler, aynı kadrandaki daimi ikinci azı diş jermlerinin Nolla kalsifikasyon aşamasına göre, uygun zamanlama (Grup 1- Nolla 6. veya 7. aşama) ve geç zamanlama (Grup 2- Nolla 8. veya 9. aşama) olarak iki gruba ayrılmıştır. 24. ayda klinik/radyolojik/fotoğrafik verilere dayanarak, spontan boşluk kapanmasının başarısı, komşu dişlerin rotasyon dereceleri ve dişsel orta hat sapmaları değerlendirilmiştir.* ***Bulgular:*** *Grup 1'de %52 oranında başarılı spontan boşluk kapanması tespit edilirken, Grup 2'de başarılı sonuç bulgulanmamıştır. Fark istatistiksel olarak anlamlı düzeydedir ($p<0,001$). Komşu dişlerin rotasyonları Grup 2'de daha çok görülmüş ve aradaki fark istatistiksel olarak anlamlı bulunmamıştır ($p=0,138$, $p=0,084$, $p=0,120$). Dişsel orta hat sapmaları, tek taraflı çekimlerde çift taraflı çekimlerden istatistiksel olarak anlamlı derecede yüksek bulunmuştur ($p=0,006$).* ***Sonuçlar:*** *Başarılı spontan boşluk kapanması için, daimi alt birinci azı diş çekimlerinin zamanlaması, daimi alt ikinci azı dişlerin Nolla sınıflamasına göre 6. veya 7. gelişim aşamasında planlanmalıdır. Komşu dişlerdeki rotasyonlar çekim zamanlamasına bakılmaksızın gelişebildiği için, vakalar izlenmeli ve gerekirse müdahale edilmelidir. Ek olarak, dişsel orta hat sapmasına neden olduğu için, tek taraflı daimi alt birinci azı diş çekiminden olabildiğince kaçınılmalıdır.*

Anahtar Kelimeler: *Diş Çekimi, Diş Oklüzyonu, Maloklüzyon.*

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Original research

EFFECTS OF NANO-HYDROXYAPATITE DENTIFRICES WITH AND WITHOUT FLUORIDE ON PRIMARY TEETH ENAMEL: A MICRO-CT AND A SEM STUDY

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ABSTRACT

Objectives: The ideal remineralization system should provide sufficient ion reserves to provide mineral gain on deeper surfaces, as well as being biocompatible and easy to apply with no adverse effect. The aim of this study was to evaluate the remineralization efficiency of dentifrice form of nano-hydroxyapatite alone and its combination with fluoride on initial enamel lesions in primary teeth by micro-CT and SEM.

Materials and Methods: The enamel surfaces of 30 extracted primary incisors were treated with nano-hydroxyapatite based (nHAP), nano-hydroxyapatite-fluoride-containing (nHAP+F) and fluoride-containing dentifrice (F), respectively after the pH cycle. Mineral gain and surface properties were evaluated by micro-CT and SEM.

Results: nHAP group provided more mineral gain than fluoride containing paste groups but there was no statistically significant difference ($p>0.05$) according to the micro-CT evaluations. In SEM images, the micropores were completely covered with an apatite layer and mineral precipitations were observed to be wider and more pronounced in the nHAP group. Calcium fluoride crystalline structures exhibited non-homogeneous globular precipitations in the F Group.

Conclusions: It was concluded that nHAP dentifrice is as effective as fluoride dentifrice on initial enamel lesions in primary teeth with less caries-resistant enamel surface and therefore it can be safely used.

Keywords: Dentifrices, hydroxyapatite, microcomputed tomography, preventive dentistry, tooth remineralization.

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INTRODUCTION

Early childhood caries (ECC) is a special form of severe dental caries that affects young children and even infants.[1] Progression of caries may result in premature loss of primary anterior teeth leading to impaired quality of life.[2-53] In order to manage the progression of ECC, the effectiveness of preventive treatments varies depending on the early diagnosis of the lesion, as well as their ability to be applied in non-invasive methods and daily routine. Today, dentifrices can serve this purpose thanks to its easy accessibility and widespread use.[3-7]

Fluoride (F), which forms a more resistant fluorapatite structure than hydroxyapatite against acid attacks, is the most widely used agent for remineralization.[3-7] It has been understood that the mechanism of remineralization with topical fluorides is limited to the increase in surface hardness and resistance to demineralization only as a result of chemical and physical modification of the existing apatite surface, rather than recovering the lost minerals to form a new apatitic layer.[6-8,10]

Based on the knowledge that superficial remineralization has a limited impact on improving aesthetic and structural properties, it is accepted that the ideal remineralization system should provide mineral recovery on deeper surfaces.[7] Hydroxyapatite (HAP) has started to be used in the reconstruction of tooth enamel as a biocompatible and bioactive material.[11-15] Following the advances in nanotechnology, the initial enamel lesions could able to be repaired with nano-sized hydroxyapatites (nHAP), based on the knowledge that the surface porosities were better retained by increasing the surface areas of the hydroxyapatites which were incorporated into dentifrices.[11,16,17] In addition to several studies demonstrating that its use alone provides remineralization[8,10,12,17-19], there are also studies comparing the use of materials alone with their combined use to determine if nHAP has a synergistic effect with fluoride.[20-23]

Scanning electron microscopy (SEM), which allows a detailed examination of the topographic structure of the enamel surface is used as the gold standard in many in-vitro studies.[9,17,24,25] Besides SEM, micro-CT examination is also an innovative and non-invasive procedure. Micro-CT has the ability to determine the mineral loss of the initial enamel lesions and make quantitative measurements. However, there was no study evaluating the effect of remineralization of nHAP and fluoride-containing dentifrices on enamel lesions in primary teeth using micro-CT.

In this *in-vitro* study, it was aimed to evaluate the remineralization effect of the nano-hydroxyapatite dentifrice alone and with a combination of fluoride on the initial enamel lesions by micro-CT and SEM.

MATERIALS AND METHODS

30 extracted maxillary primary incisors were used in this *in-vitro* study. The written consent forms were signed by the parents. Ethics committee approval was obtained from the Clinical Research Ethics Committee (36290600/104). The study followed the principles of the Declaration of Helsinki.

Groups were planned according to remineralization materials as F group, nHAP+F group and nHAP group. Remineralization materials were tested on the three divided windows of the same sample as -intact enamel without any treatment (control group), initial enamel lesion not exposed to the pH cycle (demineralization group) and initial enamel lesions exposed to pH cycle and dentifrice application (remineralization group). Teeth were randomly divided into three groups (n=10).

The surfaces of the teeth were examined by a stereomicroscope (Leica MZ12, Meyer Instruments, Houston, TX, USA) to ensure that there was no visible structural defect. Teeth were brushed with a soft brush under water and stored in 0.1% thymol solution.

Prior to the experiments, the teeth were embedded in acrylic molds to cover all surfaces except buccal enamel surfaces. All parts were coated with 2 layers of acid-resistant nail polish except the 3x3 mm area on the buccal surfaces. The area of 3x1 mm thickness in the middle of the buccal surface was covered with 2 layers of nail

polish to be used as a control group. The other two areas of 3x1 were exposed to acid gel in order to create an initial enamel lesion (Figure 1).

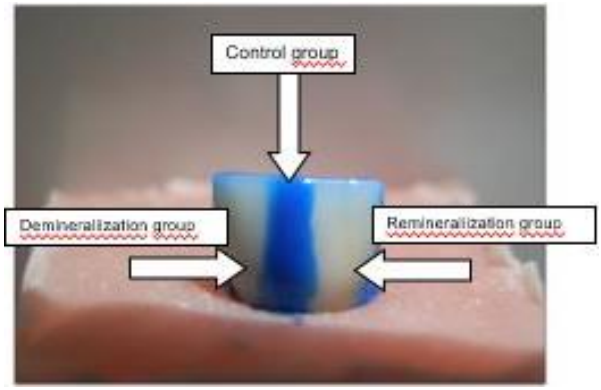

Figure 1: Intact enamel without any treatment (control group), initial enamel lesion not exposed to the pH cycle (demineralization group) and initial enamel lesion, exposed to pH cycle and dentifrice application (remineralization group) surfaces in the tooth sample

Initial enamel lesion creation

The acid gel technique used in the formation of the initial lesions contains -8% carboxymethyl cellulose and -0.1 mol/l lactic acid and its pH was adjusted to 4.5 with potassium hydroxide (KOH). Specimens were placed in a container containing acid gel and incubated for 96 hours in an oven (Kottermann, 3044, Germany) with a temperature of 37°C.

pH cycling

One of the two remaining windows with the initial enamel lesion was closed with nail polish after acid gel application and used for surface evaluation prior to the pH cycle. The last window which was left open with the nail polish uncoated surface was used for surface evaluation after the application of pH cycle and remineralization materials together.

During the demineralization-remineralization cycle applied to the samples in order to simulate the pH changes occurring in the oral environment throughout the day; 3-hour demineralization solution (2.2 mM $CaCl_2$, 2.2 mM NaH_2PO_4, 0.05 mM acetic acid, pH 4.4 with KOH), 2-hour remineralization solution (1.5 mM $CaCl_2$, 0.9 mM NaH_2PO_4 (0.15 mM KCl, pH 7.0), 3-hour demineralization solution, and 16-hour remineralization solution was applied, and 24-hour pH cycle was completed.[18]

Remineralization materials used in the study were Colgate Optic White (Colgate&Palmolive Company, 1000 ppm NaF) for F group, Ultradex Recalcifiying and Whitening (Periproducts, 1% nHAP + 1000 ppm NaF) for nHAP+F group and Apacare Apakids (Apagard, 1% nHAP) for nHAP group. Remineralization materials were weighed on a sensitive balance and then they were gently applied on the teeth twice daily (at 9:30 am and 7:30 pm) and for 2 minutes during the pH cycle (7 days) using a standard-sized applicator.

Each test material was removed under running water after application, then the samples were placed back into the containers. In order to maintain the effectiveness of the demineralization and remineralization solutions, the solutions were freshly prepared and renewed daily.

Micro-CT Analysis

Hydroxyapatite blocks (Skyscan, Kontich, Belgium) obtained from calcium hydroxyapatite (HAP) crystal were used to calibrate the micro-CT and to prevent x-ray hardening artifact.

The parameters were set to 100 kvp, 100 mA and 13.7 micrometers/pixel and the rotation step was 0.5 to match the scan values of the HAP blocks. For other parameters, X-ray hardening correction was applied, optimal contrast settings were set to 0-0.05 and used for reconstruction of samples. Each scanned tooth was then reconstructed using NRecon software. In total, 726 2-dimensional axial projections were obtained for each image group. These two-dimensional axial projections were then prepared for analysis by the manufacturer's software, Computer Tomography Analyze (CTan) (version 1.14,4,1 Skycan, Kontich, Belgium).

CTan software was used for advanced volumetric analysis and depth measurements of samples reconstructed with NReconstruction (NRecon) software. The starting and ending zones were selected for each tooth on the program. Since there are 3 different regions on a tooth in the present study, the area to be analyzed in CTan program was divided into left, middle and right. Afterwards, different Region of Interest (ROI) in the selected area was determined for the measurement of mineral density and gray color

values by applying adaptive interpolarization for each tooth.

The selected ROIs were then calculated using the CTan program for Bone Mineral Density (BMD). Mineral concentrations were calculated automatically by the program using the calibration curve generated with the aid of HAP calibration blocks. The densities of ROIs were then compared. Images, photos and videos were prepared with CTvox (version 2.7.0.).

SEM Analysis

Following the micro-CT analysis, 3 randomly selected samples from each group were taken to the Metallurgical Engineering Department of the Middle East Technical University for SEM examination. After all surfaces were coated with gold, images were taken from three different regions on each sample in ×500, ×2500 and ×5000 magnifications.

Statistical Analysis

SP IBM SPSS Statistics Version 22 package program was used to evaluate the results of the study. "One Way Analysis of Variance (ANOVA) Test" was used to evaluate the mineral density difference between the groups. When examining the difference between the groups; 0.05 was used as the level of significance.

RESULTS

Micro-CT Findings

Intra-group and intergroup comparisons of the mineral density measurements of all three surfaces -intact enamel without any treatment (control group), initial enamel lesions not exposed to the pH cycle (demineralization group) and initial enamel lesions exposed to pH cycle and dentifrice application (remineralization group)- were made by micro-CT.

Within each F, nHAP+F and nHAP groups, the mineral density of the demineralization groups was significantly lower than the other two groups ($p<0.05$). There was no significant difference between the remineralization group and the control group. Although there was no statistical difference, remineralization groups had higher mineral density in fluoride dentifrice (F) and nano-hydroxyapatite dentifrice (nHAP) than the control group. In the nHAP+F group, the control group had a higher mineral density than the remineralization group.

When the mineral gain of three dentifrices on initial enamel lesions after the pH cycle was examined between the groups, the values were; F group was found to be 0.0965 g/cm^3, nHAP+F group was 0.0978 g/cm^3 and nHAP group was 0.1162 g/cm^3. No significant difference was found between the groups according to the mineral density difference between the remineralization and demineralization groups. In general terms, it can be said that the order of gain in mineral amount between the groups is nHAP> nHAP+F> F (Figure 2).

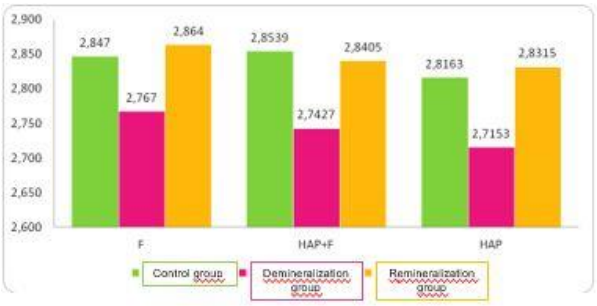

Figure 2. Comparison of mineral density difference between remineralization-demineralization-control groups in all treatment protocol

The increase in mineral content of the initial enamel lesions in the dentifrice group containing nano-hydroxyapatite was higher than the paste groups containing 1000 ppm F, although not statistically significant (Figure 2, Table 1).

Table 1: ANOVA test results for intergroup difference

	N	Med.	Std. Dev.	Min.	Max.	F value	P value
F	10	0.016500	0.0458191	-0.0610	0.0960		
HAP+F	10	-0.013400	0.0767003	-0.0850	0.1730	0.496	0.615
HAP	10	0.015200	0.0964743	-0.1340	0.2300		

SEM Findings

In the enamel samples demineralized to form an initial enamel lesion, it was found that the tooth enamel surface had a smooth and uniform structure before being exposed to any remineralizing agent and that the enamel prisms were viewed as key holes.

On the demineralized surfaces of all samples, it was observed that the surface layer of the enamel was disrupted and micropores were exposed in accordance with the prism structure. Deterioration of the integrity of enamel prisms and more dissolution in the central part of the prisms than the periphery part resulted in honeycomb-like images in these regions. However, it has been observed that the prism periphery has also disappeared and large pits have been formed in some regions.

It was observed that enamel surfaces were covered with newly formed CaF_2 crystals after the treatment of initial enamel lesions with F dentifrice (Figure 3a). It was observed that remineralization on initial enamel lesions did not show a homogeneous flat surface. It has been determined that small globules formed in some regions combined to form larger globules. However, the surface of some micropores was not covered and there were gaps in some places.

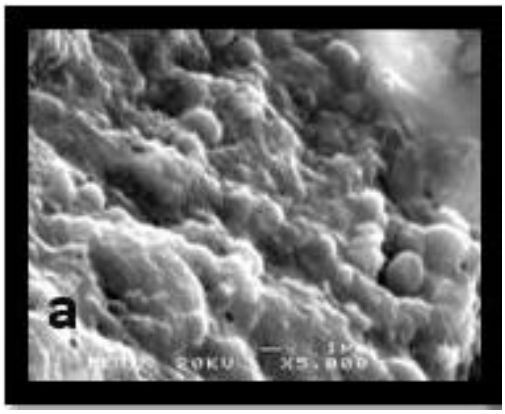

Figure 3a. Remineralization surface of the F group ×5000 magnification.

When the enamel surfaces treated with nHAP+F containing dentifrice were evaluated by SEM, it was determined that the whole surface had a homogeneous appearance and crystal accumulations of different diameters formed on the new surface layer (Figure 3b).

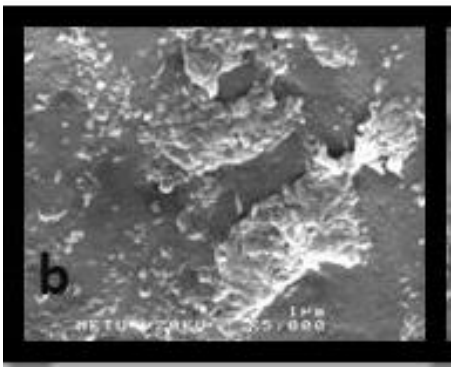

Figure 3b. Remineralization surface of the nHAP group ×5000 magnification.

In the samples treated with nHAP dentifrice, it was observed that the porous structure on the enamel surface formed after demineralization completely disappeared and the whole surface was covered with a new homogenous remineralization layer (Figure 3c).

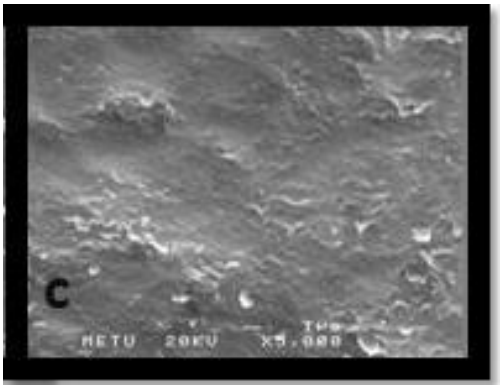

Figure 3c. Remineralization surface of the nHAP+F group ×5000 magnification.

The fact that the obtained surface cover provided the complete disappearance of the porous structure of the initial enamel lesions demonstrated that the thickness of this newly formed layer was higher than that observed after the application of F and nHAP+F dentifrice. It is also noteworthy that large scale mineral deposits were present in some regions.

DISCUSSION

The aesthetic restorations of the primary incisors may present some difficulties for both the practitioner and the pediatric patient. Therefore, in early childhood caries cases, early diagnosis, prevention, and even reversal of the initial enamel lesions have become increasingly important.[1-7] At this point, the concept of remineralization has come into the picture.[1,3-7]

The effectiveness of the method and the product used in protective programs should be

strong as well as easy to apply and low in cost, not requiring a professional application, reaching everyone with the individual application.[3,26] When the studies evaluating the effectiveness of remineralization of nano-hydroxyapatite in primary teeth are examined; it was observed that only three of them used dentifrice.[13-15] Only two of these studies had a fluoride comparison group[14,15] and generally surface hardness assessments were made.[12-15] In this context, in the present study, it was aimed to investigate the efficacy of different dentifrices due to their remineralization capacity through the evaluation of mineral changes on the enamel surfaces of primary teeth by micro-CT.

Recently, nHAP is considered one of the most biocompatible and bioactive materials; it has been studied as a biomimetic material that has demonstrated the potential effect of remineralizing of initial enamel caries under dynamic pH-cycling conditions.[12-14] The presence of hydroxyapatite material, which is the main structure of enamel, seems quite reasonable in terms of preventing the enamel demineralization and increasing its remineralization. HAP crystals in nanostructures have high biomimetic properties due to their composition, structure, morphology, body, and surface physical-chemical properties.[10,24,27] Dentifrices with nHAP are known to have a positive impact on the remineralization of initial enamel lesions, but there is no precise information on the repair mechanism of the lesions and more researches are needed.[17,27] Therefore, in this study, it was aimed to investigate the effectiveness of the remineralization of dentifrices with nano-hydroxyapatite in comparison to fluoride-containing.

Although the amount of fluoride in pediatric dentifrices varies between 250-500 ppm, it is stated that children with a high risk of caries under 6 years of age can use dentifrices containing 1000 ppm fluoride in the amount of swabs.[3,6] In addition, according to an in situ study and a systematic review evaluating the efficacy of different concentrations of fluoride dentifrices in remineralization of primary teeth enamel, it was stated that dentifrices containing at least 1000 ppm fluoride should be used in order to achieve effective remineralization.[29,30] For these reasons, in this study, a dentifrice containing 1000 ppm which is indicated to have optimum remineralization efficiency, was preferred.

In an *in-vitro* study by Itthagarun *et al*.,[18] in which they aimed to evaluate the effectiveness of remineralization on initial lesions of a dentifrice containing 10% nHAP with a dentifrice containing 950 ppm F, it was found that the same amount of reduction in lesion depth and the remineralization effects were similar. The fact that dentifrices with fluoride and nHAP did not show a significant difference between the mineral gain on initial enamel lesions in the present study also supports that view.

However, in the present study, although not statistically significant, the mineral density values of the remineralization group of nHAP dentifrice were higher than the fluoride dentifrice group. It was similar to an *in vivo* study which reported that the remineralization efficacy of nHAP was more successful than other dentifrices as a result of comparing the remineralization and reparability of different dentifrices on the enamel surface of premolar teeth.[31] In another study, the mineral gain of nHAP-containing dentifrices at the end of the 5-week cycle was found to be statistically significant than that of aminofluoride dentifrice on the initial enamel lesions on bovine specimens.[32]

There are also studies investigating whether there would be a synergistic effect by taking advantage of fluoride.[20,23,33,35] Whereas in a few studies the remineralization effect is reported to be increased[34,35], a number of investigators have found no synergistic interactions with fluoride.[20-23] In addition to those studies, it was reported that the biocompatibility of fluoride ions is adversely affected when used with nHAP.[36] In a study evaluating the remineralization effect of nHAP and nHAP+F combination in dentifrice form, initial enamel lesions were evaluated with microhardness and only HAP-containing dentifrice was found to be effective in increasing surface hardness.[20] In the present study, it was also detected that within the nHAP+F group,

mineral density values of the remineralization group could not reach to the baseline values. Consequently, based on micro-CT findings of the present study, it can be concluded that the addition of fluoride to the nHAP-containing dentifrices has no synergistic effect on remineralization. However, it can be stated that the gain in the mineral amount in the nHAP+F group was higher when compared to the F group, although not statistically significant.

In an *in vitro* study comparing the effect of dentifrices containing nHAP and sodiumfluoride on initial enamel lesions, it was observed that nHAP group had a unique form of remineralization.[12] While the remineralization surface of hydroxyapatite dentifrice was found to be smooth, it was found that the remineralization of fluoride dentifrice was irregular and resulted in non-homogenous layer, and some micropores did not close. It has been also reported that the modifications seen on the enamel surface were non-uniform irregular globular structures.[8,12,15] Similar to these studies, it was observed that the surface treated with fluoride dentifrice was irregular and rough in the present study.

The most prominent advantage of nano-hydroxyapatite in preventive dentistry when compared to other agents is that it hardens the existing superficial layer and creates a remineralization mechanism where superficial porosities are covered with a uniform and thick new synthetic hydroxyapatite layer.[8-10,14-16] Similar to these studies, in the present study's SEM images of the enamel surfaces treated with hydroxyapatite-fluoride combination dentifrice, the whole surface had a homogeneous appearance and crystal accumulations of different diameters and the globular deposits did not cover the whole surface. The finding that the remineralization surface in the samples treated with nHAP dentifrice has a more intense mineral deposit than the intact enamel confirms the opinion that a more durable structure was formed than before.

CONCLUSIONS

Within the limitations of this study, based on the findings obtained from micro-CT and SEM images, it can be concluded that the remineralization mechanism of nHAP works by forming a layer with high mineral density by apatite deposition on the demineralized surface and repairing the crystal structure of the enamel by using a mineral deposition. In addition, it is thought that this layer may act as a mineral reserve against acid attacks and inhibit demineralization. The hypothesis that "nHAP has a similar fluor-like remineralization effect" is disproved as it creates more effective mineral exchange than fluoride dentifrice. It is thought that it can be recommended for effective prevention especially in children between the ages of 6 months-2 years to be used safely since there is no harm in swallowing hydroxyapatite. However, the findings need to be supported by further *in vivo* studies in order to clinically prove the efficacy of nHAP on remineralization.

ACKNOWLEDGEMENTS

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest related to this study.

Florid İçeren ve İçermeyen Nano-hidroksiapatitli Diş Macununun Süt Dişi Minesi Üzerine Etkileri: Mikro-BT ve SEM çalışması

ÖZ

***Amaç**: İdeal remineralizasyon sistemi, ağız ortamına yeterli iyon rezervini sağlayarak daha derin yüzeylerde mineral kazanımını sağlamalı ve kolay uygulanabilir olmalıdır. Çalışmamızda; nanohidroksiapatit materyalinin macun formunun tek başına kullanımı ve floridle kombinasyonunun, süt dişi başlangıç mine lezyonlarında remineralizasyon etkinliğinin mikro-BT ve SEM ile in-vitro koşullarda değerlendirilmesi amaçlanmıştır. **Gereç ve yöntemler:** Çekilmiş 30 adet üst süt kesici dişin mine yüzeyine pH döngüsünü taklit eden bir düzenek içerisinde sırasıyla; nanohidroksiapatit esaslı (nHAP), nanohidroksiapatit-florid içerikli (nHAP+F) ve florid içerikli diş macunu (Kontrol Grubu) (F) uygulamasından sonra yüzeylerindeki mineral değişimlerinin tanısı ve miktarı Mikro-BT ile, yüzey morfolojisindeki değişimler ise SEM ile değerlendirilmiştir. **Bulgular:** nHAP grubunun florid içeren macun gruplarına göre yapılan*

ölçümlerde sayısal değer bakımından daha fazla mineral kazancı sağladığı ancak bu farkın istatistiksel olarak anlamlı olmadığı belirlenmiştir (p>0.05). nHAP içeren diş macunuyla tedavi edilen örneklerin SEM bulguları değerlendirildiğinde demineralizasyon sonrası yüzeyde belirgin olarak görülen mikroporları tamamen kaplayan bir apatit tabakası oluştuğu gözlenmiştir. F'li diş macunu grubundaki örnekler de ise; mine yüzeyinde düzensiz, homojen olmayan ve kalsiyum florür kristali olduğu tahmin edilen yapıların globüler olarak çökelmeler gösterdiği, bununla birlikte bazı mikroporların yüzeyinin örtülmediği ve yer yer boşluklar olduğu gözlenmiştir. ***Sonuçlar:*** *Nano-hidroksiapatit içeren diş macunlarının, çürüğe daha az dirençli mine yüzeyine sahip olan süt dişlerinde florid içeren macunlar kadar etkili bir remineralizasyon etkisi oluşturduğu ve çocuklarda floridli macunlara alternatif olarak güvenle kullanılabileceği düşünülmektedir.* ***Anahtar Kelimeler:*** *Diş macunları, hidroksiapatit, koruyucu diş hekimliği, mikrobilgisayarlı tomografi, diş remineralizasyonu*.

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Original research

ASSESSMENT OF CARIES PREVALENCE AND ASSOCIATED RISK FACTORS AMONG TURKISH CHILDREN IN EDIRNE, TURKEY

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ABSTRACT

Objectives: Dental caries has a multifactorial etiology that has been associated with many risk factors such as improper dietary habits, poor oral hygiene, parental education and socioeconomic status of family. It is essential to identify the potential risk factors to improve the oral health of children. The aim of the present study is to evaluate dental caries prevalence and potential risk factors in a group of Turkish children residing in Edirne province.

Materials and Methods: Data of 704 children aged between 7 to 12 years old, who applied for examination/treatment to the Department of Pediatric Dentistry between April 2016 through June 2018 were evaluated for the present study. Dental caries status was recorded using the number of decayed, missing or filled teeth (dft/DMFT) and decayed, missing or filled surface (dfs/DMFS) indices. A structured questionnaire inquiring sociodemographics information, oral hygiene habits, and diet history of the children were employed to parents.

Results: The sample comprised of 365 males and 339 females. From overall children, 31.11% were caries-free, while the caries prevalence was found 68.89%. Dental caries scores of all children included in the study were calculated as dft: 4.97±4.02, dfs: 11.85±11.82 for primary teeth and as DMFT: 2.63±2.42 DMFS: 3.81±4.34 for permanent teeth. Statistically significant differences were found between age groups according to caries prevalence in the primary dentition ($p<0.05$). Dental caries was associated with educational level of mother ($p<0.05$), educational level of father ($p=0.02$), gender ($p= 0.007$) and family income ($p=0.03$).

Conclusions: The high prevalence of dental caries highlights the importance of comprehensive oral health interventions to improve the oral health of children residing in Edirne, Turkey.

Keywords: Child, dental caries, oral health.

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INTRODUCTION

Oral diseases have an increasing effect on the health and wellbeing of children worldwide. The burden of oral diseases is still very high; in particular, dental caries affects between 60–90% of schoolchildren. Epidemiological evidence indicates that dental caries is a common and chronic disease that results in pain, infection and consequently, loss of the affected tooth if remain untreated.[1,2]

Dental caries that is a multifactorial disease develops as a consequence of acids produced from the fermentation of carbohydrates by cariogenic bacteria which results in demineralization of dental hard tissues.[3] Nutritional transition with easy access to refined carbohydrates, poor tooth brushing habits, low level of awareness, educational level and socioeconomic status are some factors that are involved in the development of dental caries.[4,5] The prevalence and severity of dental caries are thought to be associated with several risk factors, including socioeconomic status and educational level, dietary habits and oral hygiene practices.[6,7,8] Children who develop dental caries on their primary teeth in younger age are more prone to develop dental caries in their permanent dentition.[9] Therefore, assessment of caries risk and follow up with regular intervals are strongly advised for children with increased risk of dental caries.[10,11,12]

Edirne is a city which is located in the northwestern border of Turkey. Children residing in this city are mostly referred for their routine dental examinations and treatments to the only university-based pediatric dental clinic. In the Pediatric Dentistry Department importance is being given to preventive programmes that focus on improving oral health of children. For that reason, epidemiological studies that represent the oral health status of a specific population are needed to develop adequate oral health care programmes in this region.[13]

The aim of the present study was to evaluate dental caries prevalence and potential risk factors among a Turkish subpopulation living in Edirne, Turkey.

MATERIALS AND METHODS

Study Design

The study was approved by the Ethics Committee of the Trakya University Faculty of Medicine (TÜTF-BAEK 2018/368) and was carried out in agreement with the Declaration of Helsinki principles. Data of 704 children aged 7 to 12 years old who applied to the Department of Pediatric Dentistry Clinic between June 2016 and October 2018 were evaluated. All children whose parents completed the questionnaire and provided written consent were enrolled in the study.

Dental Examination

Three calibrated examiners performed dental examinations at the pediatric dentistry clinic. The calibration of inter-examiner reproducibility and inter-examiner reliability was performed on 20 children. Kappa value for intra-examiner was found 0.91, and inter-rater reliability was calculated as 0.89. The status of dental caries was recorded using the guideline of World Health Organization (WHO) Oral Health Survey Basic Methods 1997.[14] Caries experience on permanent teeth was measured using DMFT index while dft index was used for primary teeth. The presence of caries was diagnosed if dft/DMFT> 0.

After dental examination, the parents were asked to fill a standardized questionnaire consisting of two parts. The first part consists of sociodemographic information, whereas the second part includes oral hygiene practices and dietary habits related questions as consumption of sweet snack (mean intake frequency/day), frequency of toothbrushing, use of toothpaste. The consumption of sugary snacks was investigated as never, 1-3 times a day and more than three times a day. The frequency of toothbrushing was evaluated as either or more than twice a day and less than twice a day. The economic status of the family was categorized as low, middle and high income. The educational level of both parents was also used as a representative of the socioeconomic level of the family.

Data analysis

Statistical analysis was performed using The IBM SPSS® version 22 (IBM Corp., NY, USA). A descriptive statistical analysis was performed. The chi-square test was used to evaluate the

relationships between the parameters with a statistical significance level of $p < 0.05$.

RESULTS

Data of a total of 704 children, 365 (51.85%) males and 339 (48.15) females with a mean age of 9.35±1.67 were evaluated in the study (Table 1).

Table 1. The distribution of children according to age and gender

	Male n (%)	**Female n (%)**	**Total n**
Children n (%)	365 (51.85%)	339 (48.15%)	704
Age (Mean ±SD)	9.39 ±1.68	9.29 ±1.66	9.35±1.67

n Number of the patients, % percentage.

The distribution of gender, according to age groups, are presented in Table 2.

Table 2. The distribution of gender according to age groups

Age (years)	**Male (n=365)**	**Female (n= 339)**
7-8 (n=249)	122	127
9-10 (n=265)	146	119
11-12 (n=190)	97	93

n Number of the patients

Oral health attitudes and dietary habits are shown in Table 3.

Table 3. Distribution of oral health behaviour and daily sweet snack consumption of children

		n	**%**
Tooth brushing frequency (times per day)	≥ 2	425	60.37%
	< 2	279	39.63%
First brushing age (years)	≤ 3	337	47.87%
	>3	367	52.13%
Toothpaste usage	Yes	660	93.75%
	No	44	6.25%
Frequency of daily sweet snacking (times per day)	1-3 times	426	60.51%
	>3 times	244	34.65%
	None	34	4.84%

n Number of the patients, % percentage.

The mean age of the first dentist visit was found at 7.59 ± 2.42. In the whole sample, the mean and standard deviation of decayed, missing, filled tooth surfaces values were found as; dft: 4.97±4.02, dfs:11.85±11.82, DMFT:2.63±2.42 and DMFS: 3.81±4.34 for all group.

The distribution of caries experience by gender is displayed in Table 4.

Table 4. Dental caries experience according to gender

	Male (n=365)	**Female (n= 339)**	***p*-value**
dft Mean±SD	5.11 ± 4.08	4.81±3.96	0.316
dfs Mean±SD	12.25±11.62	11.42±12.04	0.338
DMFT Mean±SD	2.50±2.53	2.76±2.29	0.151
DMFS Mean±SD	3.79±4.69	3.84±3.92	0.848

Chi-Square test *Statistically significant at p<0.05.

No statistically significant differences were found between caries experience and gender (p>0.05). The age distribution of the caries experience is displayed in Table 5.

Table 5. Dental caries experience according to different age group

Age (years)	**7-8 (n=249)**	**9-10 (n=265)**	**11-12 (n=190)**	***p*-value**
dft Mean±SD	7.26 ±3.78	5.23 ±3.37	1.63 ±2.72	**0.000***
dfs Mean±SD	17.25±12.35	12.8±11.14	3.53 ±6.09	**0.003***
DMFT Mean±SD	1.67 ±1.84	2.72±1.80	3.73±3.22	0.534
DMFS Mean±SD	2.24 ±2.98	3.93±3.62	5.7±5.76	0.480

Chi-Square test *Statistically significant at p<0.05.

Children were divided into three age groups, as 7-8 year-old (35.37%), 9-10 year-old (37.64%) and 11-12 year-old (27.01%). Statistically significant differences were found between age groups according to caries prevalence in the primary dentition (p<0.05). However, there were no statistically significant differences in DMFT and DMFS scores at different age groups (p>0.05).

There wasn't any statistically significant difference in caries prevalence according to the educational level of the mother, as shown in Table 6 (p>0.05).

Table 6: Dental caries experience according to educational level of mother

	Primary School 383(54%)	**High School 185(26%)**	**University 168(24%)**	***p* value**
dft Mean±SD	4.91 ± 4.19	5.292 ± 4.04	4.68 ± 3.48	0.375
dfs Mean±SD	11.90 ± 12.67	12.92 ± 11.80	10.213 ± 8.94	0.205
DMFT Mean±SD	2.88 ± 2.46	2.48 ± 2.42	2.08 ± 2.17	0.867
DMFS Mean±SD	4.50 ± 4.73	3.30 ± 4.04	2.55 ± 3.00	0.598

n Number of the patients % percentage.
Chi-Square test *Statistically significant at p<0.05.

Statistically significant differences were found only at DMFS index scores according to the educational level of father presented in Table 7 (p<0.05).

Table 7: The distribution of educational level of father and caries prevalance

	Primary School 312 (44%)	**High School 224(32%)**	**University 168(24%)**	***p* value**
dft Mean±SD	5.18±4.31	4.80±3.90	4.78±3.60	0.595
dfs Mean±SD	12.89±13.24	11.20±10.92	10,75±9.91	0.519
DMFT Mean±SD	2.74±2.38	2.48 ± 2.42	2.14±2.04	0.062
DMFS Mean±SD	4.19±4.44	4.14±4.80	2.65±3.12	**0.042***

n Number of the patients, % percentage. Chi-Square test *Statistically significant at p<0.05.

The parental income was not significantly associated with the caries prevalence of children shown in Table 8 (p>0.05).

Table 8. The caries experience of children according to family income level

	Low income (n=302)	Middle income (n=202)	High income (n=200)	*p* value
dft Mean±SD	5.11±4.22	4.75±4.10	4.96±3.63	0.621
dfs Mean±SD	12.39±12.76	11.59±12.00	11.25±10.06	0.537
DMFT Mean±SD	2.76±2.46	2.69±2.51	2.37±2.23	0.182
DMFS Mean±SD	4.36±4.65	3.73±4.36	3.08±3.69	0.262

n Number of the patients.
Chi-Square test *Statistically significant at p<0.05.

Among all children, 31.11 % were caries-free, while the caries experience (sum of decayed, filled and missing teeth due to caries) was found 68.89% (p<0.05). Statistically significant differences were found between parental education level (p<0.05), gender (p= 0.007) and family income level (p=0.030) among children with and without dental caries shown in Table 9.

Table 9. Distribution of children according to caries experience

	Caries -free (n=219) 31.11%	Caries-active (n=485) 68.89%	*p* value
Gender			
Female (n=339)	90	249	**0.007***
Male (n=365)	129	236	
Mother Education			
Primary School 383(54%)	101	282	
High School 185(26%)	64	121	**0.001***
University 136(19%)	54	82	
Father Education			
Primary School 312 (44%)	97	225	
High School 224(32%)	69	155	**0.020***
University 168(24%)	63	105	
Family Income			
Low income (n=302)	83	219	
Middle income (n=202)	65	136	**0.030***
High income (n=200)	71	129	

Chi-Square test *Statistically significant at p<0.05.

DISCUSSION

Dental caries developing during childhood continues to be a significant public health concern that needs a worldwide consideration for prevention and treatment.[15,16,17] The assessment of its prevalence, together with the associated risk factors, has a significant role in improving oral health. Careful monitoring and preventive interventions could decrease the risk for dental caries and reduce the need for invasive treatment procedures.[15] The present study aimed to evaluate the prevalence of dental caries and potential risk factors in a group of Turkish children attending to Department of Pediatric Dentistry.

The prevalence of dental caries in this study was found as 68.89% with the mean dft score of 4.97 and mean DMFT score of 2.63 for all children. The general data about the dental caries

prevalence of children in Turkey comes from the two surveys of 1988 and 2004 in which the caries prevalence and DMFT score of 12-year-old children were found as 84% and 2.7 in 1988, and as 61% and 1.9 in 2004.[18,19]Aktas *et al.*[20] reported the mean dft score of 5 to 15 years old Turkish children as 4.25 and the mean DMFT score as 2.34. Cantekin *et al.*[21] evaluated the association of body mass index and dental caries in their study and reported the mean DMFT scores of 12-year-old Turkish children as 1.75. Another study which evaluated the dental health status of Turkish children reported the prevalence of dental caries as 61.1% at age 12 and DMFT score was found as 1.9 for 12 year-old school children.[22] In the present study, caries prevalence and DMFT score of 12-year-old were found 74.25% and 3.73. The mean DMFT score reported in our study was higher than the results of the national surveys conducted in 1988, 2004 and the other studies from Turkey. Prevalence of dental caries in some countries around the world was found as 75% in Brazil[23], 37% in Kenya[24], 30.5% in Sudan[25], and 21.8% in Bahirdar city Ethiopia.[26] All the above-mentioned studies followed DMFT/dft index to assess the dental caries prevalence. In the present study, caries prevalence was determined by using DMFT/dft index established by WHO.[14] The difference with these studies might be due to different study population and the social and demographic variations between those countries.[13]

Faroogi *et al.*[27] reported caries prevalence among 6-9 years-old children as 77. 8% with a mean dft score of 3.66, while in children aged between 10 - 12, the caries prevalence was found 68% with a mean DMFT score of 1.94. Kaptan *et al.*[28] evaluated oral health status of preschool children in a Turkish subpopulation. According to their study results, the mean dft score was found as 1.63 in the three years of age group; 2.72 in the four years of age group; 3.04 in the five years of age group, and 3.64 in the six years of age group. It was also reported that the evaluation of dft scores according to different ages was found statistically significant ($p<0.05$).

In the present study, statistically significant differences were found between age groups according to caries prevalence in the primary dentition ($p<0.05$). The mean dft score of was found 7.26 and mean DMFT score was 1.67 among 7-8 year-old whereas the mean dft was 5.23 and the mean DMFT was found 2.72 among 9-10 year-old children. The advancing caries experience in permanent teeth with increasing age might be as a consequence of the caries susceptibility of newly erupted teeth with poor oral hygiene conditions. El Meligy *et al.*[29] reported in their study that the younger age groups (6-11), in case of primary teeth and the older age groups (12-13), in case of permanent teeth had a higher prevalence of dental caries which was in accordance with our study results.

In the current study, oral hygiene behaviour and consumption of sweet snack frequency (times per day) were assessed together with sociodemographic factors as risks factors for dental caries status of children. There are a few studies evaluating the behavioural and socioeconomic factors on the oral health of children in Turkey.[15, 21,30,31] According to these studies, oral health status improves and dental visit rates increase when the educational level of the parents increase.[15] Educational level of mother plays an essential role in the oral health of children and a higher socioeconomic status effects the frequency of dental visit and oral health of the children.[22] Similar to these studies, in the present study parent's education level and income level were associated with the caries experience between caries-free and caries-active children.

Bekiroglu *et al.*[30] reported that only 30.9% of the children brush their teeth once a day and 58.3% brush their teeth twice a day in their study among Turkish school children. In another study from Turkey, Dogan *et al.*[31] reported that 43.1% of the school children brushed their teeth at least twice a day, and 99.05% of children were using toothpaste. In the present study, it was found that 60.37% of the school children brushed their teeth at least twice a day; 39.63% brushed their teeth less than twice a day, and 93.75% of children were using toothpaste. Increasing knowledge and awareness of oral health can improve oral health attitudes and practices. However, oral health

cannot be improved by focusing only on health related behaviour; socioeconomic and cultural environment children are residing should also be taken into consideration.

The present study emphasizes particularly the importance of risk assessment for early intervention programs for the oral health of school children. However, it has some limitations. First of all, the study population which was selected from faculty based pediatric dental clinic, may not present all children population in this region. Furthermore, the children were evaluated only for one time and data was obtained through questionnare which may have recall bias. Therefore, further research with larger sample size are needed where the oral health status of children and related risk factors are investigated with longitudinal studies.

CONCLUSIONS

In this study population, the mean dft showed a downward trend and decreased with age. In contrast, the mean DMFT showed an upward trend and increased with age which can be concluded as regarding age groups, younger children, in their primary teeth and older children, in their permanent teeth had a higher prevalence of dental caries. Interventions, including comprehensive oral health education programs for both children and their parents, can contribute to improve oral health status of children residing in Edirne, Turkey.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

Edirne İlindeki Türk Çocuklarında Diş Çürüğü Prevelansı ve İlişkili Risk Faktörlerinin Değerlendirilmesi

ÖZ

Amaç: *Diş çürüğü, uygun olmayan beslenme alışkanlıkları, yetersiz ağız hijyen alışkanlıkları, ailenin eğitim düzeyi ve gelir düzeyi gibi çok faktörlü bir etiyolojiye sahiptir. Çocukların ağız ve diş sağlığının iyileştirilmesi için çürük oluşumunda rol oynayan risk faktörlerinin belirlenmesi oldukça önemlidir. Bu çalışmanın amacı, Edirne ilinde yaşayan okul çocuklarının çürük prevalansının belirlenmesi ve diş çürüğü ile ilişkili potansiyel risk faktörlerinin araştırılmasıdır.* ***Gereç ve Yöntemler:*** *Çalışmaya, Nisan 2016-Haziran 2018 tarihleri arasında Çocuk Diş Hekimliği Anabilim Dalı'na muayene /tedavi için başvuran 7 ile 12 yaş aralığında 704 çocuğun verileri dahil edilmiştir. Süt ve daimi dişlerdeki diş çürükleri; çürümüş, eksik veya dolgulu diş sayısı (dft/DMFT) indeksi ile süt ve daimi dişlerde çürümüş, eksik veya dolgulu diş yüzeyi (dfs/DMFS) indeksi kullanılarak değerlendirilmiştir. Ebeveynler sosyodemografik bilgiler ile beraber çocukların ağız hijyen ve beslenme alışkanlıklarına dair sorular içeren bir anket formu doldurulmuştur.* ***Bulgular:*** *Araştırmaya 365 erkek ve 339 kız dahil edilmiştir. Çürük prevalansı %68,89 olarak tespit edilmiştir. Çocukların %31,11 inde çürük gözlenmemiştir. Çalışmaya dahil edilen tüm çocukların süt dişlerindeki çürük skorları; dft: 4,97 ± 4,02, dfs: 11,85 ± 11,82 olarak, daimi dişlerinde ise DMFT: 2.63 ± 2.42 DMFS: 3,81 ± 4,34 olarak tespit edilmiştir. Diş çürükleri annenin eğitim düzeyi (p<0,05), babanın eğitim düzeyi (p=0,02), cinsiyet (p=0,007) ve gelir düzeyi (p=0,03) ile ilişkilendirilmiştir.* ***Sonuçlar:*** *Edirne ilindeki okul çağı çocuklarından tespit edilen yüksek çürük prevalansı, bu bölgedeki çocukların ağız sağlığının iyileştirilmesi için kapsamlı ağız sağlığı ve koruyucu uygulamaların gereksinimi vurgulamaktadır.*

Anahtar kelimeler: *Çocuk, diş çürükleri, ağız ve diş sağlığı.*

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Original research

COMPARISON OF SUBJECTIVE ESTHETIC PERCEPTIONS OF DENTISTS WITH DIFFERENT GENDER AND CLINICAL EXPERIENCES WITH OBJECTIVE DENTOLABIAL ESTHETIC MEASUREMENTS

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ABSTRACT

Objective: This study aimed to evaluate the consistency of specific measurable dentolabial criteria between the esthetic values accepted in the literature and the subjective opinions of physicians.

Materials and Methods: Four associate professors and four research assistants in the field of prosthodontics were selected as the examiners in the study. Photographs of smiles (focusing on the mouth region of the face) taken from 200 volunteers were examined. The results of the objective measurements of the curvature of the incisal edge and lower lip parallelism, the incisal edge and lower lip contact, the laugh line, the buccal corridor and the interincisal line and midline variables, and the subjective assessments of the evaluators were compared using Cochran's Q test.

Results: Esthetic perception is subjective; however, there was a significant correlation between the objective measurements and subjective perceptions in the incisal edge and lower lip parallelism, laugh line, and buccal corridor variables. No statistically significant difference was found between the objective computer measurements and the evaluations of the male and female examiners or between the perceptions of the specialists (associate professors) and the research assistants.

Conclusion: There is no consensus between esthetically objective findings and subjective perceptions.

Keywords: Dentolabial analysis, esthetic, subjective perceptions, prosthodontic treatment.

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INTRODUCTION

Since a smile is one of the most important means of nonverbal communication, it has an important place in an individual's social identity and self-perception.[1] A beautiful smile enables an individual to be warmly accepted in social interactions. The increasing importance of esthetics and social communication has placed greater emphasis on the prominence of smile esthetics in dental treatments.[2-5]

Esthetics is not absolute; it is highly subjective.[6] Although the perception of beauty is a subjective experience, there are some universal rules that transcend this subjectivity and provide objective criteria about what is pleasing to the human eye. These basic esthetic standards can enable clinicians to achieve satisfactory, quantitative, scientific and predictable designs.[7] The physician must understand the basic components of the smile to regulate and optimize the esthetics by understanding the complex relationships between the teeth, gum structure, and lips.[8-9]

Many studies in the literature have evaluated dental esthetics from different perspectives.[5,8,10] Mauro Fredeani[10] stated that, to achieve successful esthetic results, it is essential to plan esthetic dental and gingival treatments after the facial, dentolabial, and phonetic parameters are identified.

In the present study, the compliance of some measurable dentolabial criteria, which are subjectively evaluated by physicians who are experts in the field of prosthodontics working on smile design, is compared with objective measurements. Thus, it aimed to be a guide in terms of identifying the recommended factors for esthetic treatment planning.

MATERIALS AND METHODS

This three-stage study includes eight examiners who subjectively evaluated the smiles in the photographs of 200 volunteers as being either "esthetic" or "non-esthetic" based on five different dentolabial criteria: incisal edge parallelism, incisal edge and lower lip contact, laugh line, buccal corridor, interincisal line, and midline. The same photographs were also evaluated using objective measurements within the limits stated in the literature, and the objective results were compared with the subjective findings.

a) Study Sample

The study was carried out using the photographs of 200 volunteer participants from Zonguldak Bülent Ecevit University Faculty of Dentistry, Zonguladk, Turkey. The participants were informed about the scope of the study, and they signed a consent form. Approval for the study was obtained from the Zonguldak Bülent Ecevit University Clinical Research Ethics Committee with the conclusion 2018/24 (dated 19/12/2018 and Protocol No. 2018-246-19/12).

To eliminate the effect of color differences on esthetic perception, the following criteria were applied. Participants who had previously received orthodontic treatment or who had any restoration, coloration, or tooth deficiency at the anterior teeth, active periodontal disease, poor oral hygiene, or trauma to the jaw-face area, were excluded from the study so as not to affect the results.

b) Procedure for Taking the Photographs

To standardize the photographs, the participants were positioned with their hands hanging to the side and their feet slightly open while the head was fixed with ear bars (cephalostat) and the occlusal plane was parallel to the ground with the forehead supported (Figure 1).

Figure 1: Taking photo recordings

To ensure this parallelism, the participant was situated so that the Frankfurt horizontal plane was parallel to the ground using external reference points (porion and orbitale points).[11] Care was taken to ensure that the faces of the individuals did not contain any elements that could be distracting and affect the esthetic evaluation, such as herpes, excessive beards, piercing accessories, and intensive make-up.

Photographs were taken using a digital camera (Canon EOS 7D Mark II), macro lens (Canon EF 100mm f / 2.8L Macro IS USM), twin flash (Canon Macro Twin Lite MT-24EX), and a tripod (WT3770). The Canon 100 mm 1:1 magnification prime lens, which was used to produce all the images, was preferred to minimize the distances and magnifications due to distance. All the photographs were taken by the same person, under the same indoor artificial fluorescent lighting with a shutter speed of 1/125, an aperture of F32, and an ISO 200 setting in manual mode. The tripod and the camera were not moved until the photo shoot was finished. Using Adobe Photoshop CC 2017 (San Jose, CA, USA), the photographs were cropped to show the teeth, lips, tip of the nose, and mentolabial sulcus. The photographs were numbered from 1 to 200 and saved in Joint Photographic Experts Group (JPEG) format.

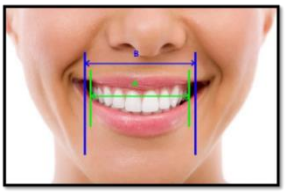
c) Selecting the Examiners and Evaluating the Photographs

Four associate professors and four research assistants from Zonguldak Bulent Ecevit University Faculty of Dentistry Department of Prosthodontics were selected as the examiners. All the photographs were delivered to the examiners using separate external memory drives and separate forms, each containing five pages. Thus, any time constraint related to the evaluation and the possibility of being influenced by each other were prevented. While examining the photographs, the examiners were informed that they should disregard the shape, arrangement, size of the teeth, and the form of the lips.

d) Determining the Criteria and Analyzing the Photographs

In this study, the most common variables, such as incisal edge and lower lip parallelism, incisal edge and lower lip contact, laugh line, buccal corridor, interincisal line, and midline, which are objectively measurable according to concrete parameters, were examined. The examination criteria and the evaluation intervals are presented the Table 1. All measurements were performed using Adobe Photoshop CC 2017.

Table 1. Summary of the criteria and range used for this study

Criterias in this study	Definition	Classification criteria in computer measurement	Measurements on Adobe Photoshop CC 2017
Incisal edge paralellism	The incisal edge or smile line is defined as an imaginary line passing through the cutting edges of the four upper-front teeth and the tip of the canine teeth.	The parallel relationship was classified as "esthetic" and the straight or reverse curvature relationship was classified as not esthetic	
Incisal edge and lower lip paralellism	It is the contact relationship of the incisal edge with the upper limit of the lower lip.	The light contact relationship was classified as "esthetic" and non-contact or covering position classified as "not esthetic".	
Laugh line	Lip line or laugh line; is the amount of teeth that appear in the vertical direction during the smile.	The middle laugh line was classified as "esthetic" and the low or high laugh line was classified as "not esthetic".	
Buccal corridor	Labial or buccal corridor (also called negative space); is the gap formed between the buccal surfaces of the posterior teeth and the corners of the mouth during smile.	Buccal corridor widths between 2-15% were classified as "esthetic" and widths outside this range were classified as "not esthetic" Proportional measurement of the buccal corridor: (A-B) / A * 100	
Interincisal line and midline	The line through the nasion and philtrum reference points is midline of the face and the line between the upper incisors is generally referenced for dental midline.	Midline deviations up to 4mm were classified as "esthetic", and deviations more than 4mm were classified as "not esthetic"	

e) Statistical Analysis

In this study, the data obtained from eight examiners and the computer measurements were transferred to the IBM SPSS V23 software program. In the data set, descriptive statistics on the data obtained as a result of the examiners' evaluations and the computer measurement were combined with all the values related to the five dentolabial variable categories. Cochran's Q Test was performed to determine the concordance between the specialists (the associate professors) (S1, S2, S3, S4) and the research assistant (A1, A2, A3, A4) examiners, between the male and female examiners, and between all the examiner subcategories and computer measurements. The analysis results are presented as frequency (percentage). Significance level was taken as $p < 0.05$.

RESULTS

The results of the compliance between all the examiners and the computer measurements for incisal edge parallelism are shown in Table 2.

Table 2. Compliance results for incisal edge parallelism

Examiners	Not esthetic*	Esthetic*	Multiple comparison	Cochran Q	p
S1	42	58	de		
S2	46.5	53.5	cd		
S3	39	61	ade		
S4	37.5	62.5	d		
A1	23.5	76.5	b	175.005	<0.001
A2	67.5	32.5	c		
A3	20.5	79.5	c		
A4	51.5	48.5	ae		
Computer	43.5	56.5	ad		

*n(%), a-e: there is no difference between examiners with the same character in each measurement.

According to Cochran's Q Test, there was a statistically significant correlation between S1, S2, S3, S4, A4, and the computer measurement (p <0.001). Moreover, there was a statistically significant correlation between all the specialists and the computer measurements (p=0.164) (Table 3).

Table 3. Compliance results for incisal edge parallelism between specialists and computer

Examiners	Not esthetic*	Esthetic*	Multiple comparison	Cochran Q	p
S1	42.5	57.5	a		
S2	46.5	53.5	a		
S3	39	61	a	6.514	0.164
S4	37.5	62.5	a		
Computer	43.5	56.5	a		

*n(%), a-e: there is no difference between examiners with the same character in each measurement.

The results of the compliance between all the examiners and the computer measurements for the relationship between the incisal edge and the lower lip variables are shown in Table 4. According to Cochran's Q Test, there was a statistically significant correlation between S1, S2, and the computer measurements (p <0.001).

Table 4. Compliance results for relationship between the incisal edge and lower lip

Examiner	Not esthetic*	Esthetic*	Multiple comparison	Cochran Q	p
S1	58.5	41.5	ae		
S2	71	29	ad		
S3	42.5	57.5	bc		
S4	50	50	ce		
A1	46	54	bce	195.868	<0.001
A2	82	18	d		
A3	53	47	ce		
A4	36	64	b		
Computer	65.5	34.5	a		

*n(%), a-e: there is no difference between examiners with the same character in each measurement.

The results of the compliance between all the examiners and the computer measurements for laugh line are shown in Table 5. According to Cochran's Q Test, there was a statistically significant correlation between S2, S3, A1, A3, A4, and the computer measurements (p<0.001).

Table 5. Compliance results for the laugh line

Examiner	Not esthetic*	Esthetic*	Multiple comparison	Cochran Q	p
S1	70	30	e		
S2	57.5	42.5	abde		
S3	49.5	50.5	d		
S4	24.5	75.5	c		
A1	51.5	48.5	ac	166.548	<0.001
A2	69.5	30.5	be		
A3	54.5	45.5	ad		
A4	51	49	abd		
Computer	52	48	ad		

*n(%). a-e: there is no difference between examiners with the same character in each measurement.

The results of the compliance between all the examiners and the computer measurements for the buccal corridor are shown in Table 6. According to Cochran's Q Test, there was a statistically significant correlation between S2, S3, A1, A3, A4, and the computer measurements ($p < 0.001$).

Table 6. Compliance results for buccal corridor

Examiner	Not esthetic*	Esthetic*	Multiple comparison	Cochran Q	p
S1	74.5	25.5	be		
S2	59.5	40.5	de		
S3	59	41	d		
S4	17	83	c		
A1	39.5	60.5	a	253.736	<0.001
A2	77	23	b		
A3	51.5	48.5	ad		
A4	38	62	a		
Computer	52	48	ad		

*n(%). a-e: there is no difference between examiners with the same character in each measurement.

The results of compliance between all the examiners and the computer measurements for the interincisal line and the midline are shown in Table 7. According to Cochran's Q Test, there was no statistically significant correlation between the examiners and the computer measurements for those two variables ($p < 0.001$).

Table 7. Interincisal line and midline alignment results

Examiner	Not esthetic*	Esthetic*	Multiple comparison	Cochran Q	p
S1	85	15	c		
S2	28	72	de		
S3	28.5	71.5	de		
S4	15.5	84.5	e		
A1	22	78	de	556.475	<0.001
A2	79	21	c		
A3	45.5	54.5	b		
A4	35.5	64.5	bd		
Computer	6	94	a		

*n(%), a-e: there is no difference between examiners with the same character in each measurement.

The compliance levels between the computer measurements and the examiners are shown in Figure 2.

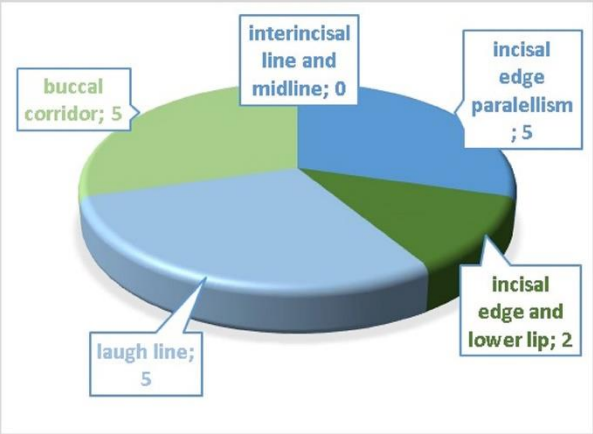


Figure 2: Schematic representation of computer measurements and rating of agreement between observers

When the findings were evaluated, in general, it was observed that there was no statistically significant agreement between the mean of all the examiners (subjective perception) and the computer measurements (objective measurements) when each dentolabial variable was compared ($p < 0.001$).

In terms of evaluating the incisal edge and lower lip contact relationship, laugh line, buccal corridor, interincisal line and midline, no statistical correlation was found between the four experienced specialists (associate professors) and the four research assistants (specialty students) and the computer measurements ($p < 0.001$). It was determined that the esthetic perception was compatible between the specialists and the computer measurements based on the incisal edge parallelism criteria ($p = 0.164$).

There was no statistically significant correlation between the four male and four female examiners and the computer measurements for all the esthetic criteria variables ($p < 0.001$).

When the entire data set was evaluated, although the difference between the specialists and research assistants and between the men and women was not statistically significant, the numerical results showed that the subjective evaluations of the specialists were comparable to the research assistants by 10/7 and the women to men by 11/6 were more consistent with the objective computer measurements (Figure 3).

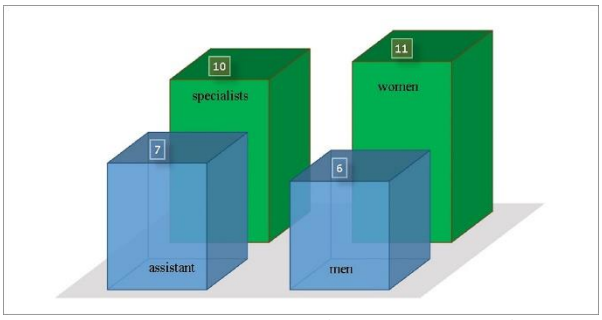


Figure 3: Schematic representation of compliance levels of specialist / assistant and female / male observers with computer measurements respectively

DISCUSSION

In previous studies, dental evaluation measurements were made on extracted teeth,[12,13] while in recent studies, plaster models, computer-based images, or intraoral evaluations have been conducted.[12,14-17] Hasanreisoglu *et al.*[14] photographed the faces of 100 dental students in full smile, obtained a plaster model from their upper jaws, and measured the anterior tooth dimensions, the presence of golden ratio, and the relationship between the facial ratios of the anterior teeth on both the models and the computer-based images. In the present study, due to the high number of samples, it was thought that taking photographs of smiles would be the most practical method, so the photographs taken from 200 students were transferred to a computer and the measurements were made in Adobe Photoshop CC 2017.

Nomura *et al.*[18], Krishnan *et al.*[19], and Chang *et al.*[20] received photographic records of posed smiles on the grounds that they were reproducible. Based on the same reasoning, in the present study, the participants were photographed with a posed smile. To avoid the factors that could affect the esthetic perception, such as hair, fashion, and eyes, and to focus on the lower 1/3 of the face, the photographs of the participants were cropped from the tip of the nose to the chin.

Esthetic perception is a subjective concept; it varies from person to person and it can be affected by situations, such as age, gender, occupational group, social status, and cultural preferences.

Accordingly, there may be a difference of opinion between dentists and individuals (laypersons) who have not received dental education.[21-24] Basaran *et al.*[25] included painters as well as specialists and laypersons in their study evaluating the effect of buccal corridors on esthetic perception because painters and specialists received esthetic training in their professions. Many studies[26-28] have shown that the oral esthetic assessments of specialists or dentists are more critical and sensitive than those of individuals who have not received dental training. Consequently, in the present study, an evaluator group consisting of four associate professors and four research assistants, who are experts in the prosthodontic department, were chosen because their awareness and discrimination were believed to be higher than general dentists. Individuals who did not receive dental training were not selected to be examiners in the study because the inclusion criteria consisted of dental terms and it was necessary to have a dental education to make an accurate assessment.

Basting *et al.*[29] compared specialists and general dentists' esthetic perceptions on smile and face photographs; they reported that the evaluations made by general dentists were more positive than the ones made by the specialists in both photography groups. Kokich *et al.*[30] examined asymmetric and symmetrical changes on the teeth; they obtained evaluations from both specialists and general dentists because they are more critical than laypersons. According to the results of the present study the scores of the specialist examiners were more compatible with the objective measurements than the scores of the research assistant examiners.

Wolfart *et al.*[31] examined the relationship between subjective judgments and objective measurements on upper anterior teeth; they reported that there was no significant difference between the subjective perceptions of men and women. Chang *et al.*[20] evaluated the variability of facial attractiveness and smile esthetics according to gender; they discovered that the raters' sex had no effect on the results. While there no statistically significant difference was found between the male and female examiners in the present study, the compliance of the subjective scores with the objective computer measurements was higher for the female examiners than the male examiners.

Different criteria have been considered in the literature to evaluate esthetic perception. The present study evaluated the most common variables (incisal edge parallelism, incisal edge and lower lip contact relationship, laugh line, buccal corridor, and interincisal line and midline) because they are objectively measurable according to concrete parameters.

Clinicians usually increase overbite so that the incisal edge follows the lower lip parallelism. Ker *et al.*[32] found that when the line passing through the incisal edges of the upper teeth follows the concave curvature of the lower lip, laypersons evaluated that to be esthetically ideal. In their study, Parekh *et al.*[33] found that ideal curved smile arches were more acceptable (84–95%) than straight smile arches, which were only 50–60% acceptable. The change of lip contour from person to person may have an effect on the smile arc, but it is critical that the line passing through the incisal edges of the upper teeth follows the lower lip in parallel.[20,32,34-36] When the results of the present study were analyzed, it was observed that five of the examiners were in agreement with the objective measurements made on the computer, while the other three did not agree with the literature knowledge about the incisal edge parallelism. Moreover, all four of the specialist examiners agreed with the objective computer measurements in terms of their esthetic views on incisal edge parallelism. The results reinforce the idea that the imaginary line passing through the incisal edges of the upper incisors is parallel to the upper limit of the lower lip in an esthetically pleasing smile.

In an ideal smile, while the central and canine teeth are required to have light contact with the lower lip, the lateral teeth are expected to be shorter in the range of about 0.5–1.5 mm from the

lower lip.[37,38] It has been reported that a smile in which the upper teeth do not contact the lower lip, or in which they slightly touch the lower lip, is more esthetic than a smile in which the teeth are covered by the lower lip.[39] When the results of the present study were examined, the computer measurement results were consistent with only two of the eight examiners. Almost all the examiners who did not comply with the objective computer measurements evaluated the incisal edge and the lower lip contact in the photographs as being more "esthetic" than "non-esthetic". This may be due to the fact that there is no esthetic consensus on the relationship between the incisal edge and the lower lip contact, or that this relationship affects esthetic perception less than other criteria.

Kokich *et al.*[30] examined the effect of the distance between the lip and the teeth on esthetic appreciation in the case of smiles; in that study, the orthodontists and laypersons both stated that gingival visibility of 3 mm or more had a negative effect on gingival appeal, and even the general dentists did not perceive the height of 4 mm to be esthetically undesirable. In another study[40], orthodontic experts found 2 mm of gingival visibility to be esthetically negative; for dentists and laypeople 4 mm of gingival visibility was found to be esthetically negative. Although these two studies stated that general dentists have a higher acceptable threshold than orthodontists, the results of both indicate that gingival visibility of 1–2 mm can be accepted as esthetically pleasing by both groups. Since the appearance of the gingiva and the upper anterior teeth decreases with aging, it may be better for the patient to have a small amount of gum visibility in a prosthetic treatment.[30] Ker *et al.*[32] considered that, while the ideal gingival visibility in a smile is 2.1 mm, lips covering the teeth with up to a 4 mm laughing line is an acceptable lower limit, and the 3.6 mm gum line is an acceptable upper limit. When the results of the present study were evaluated, agreement was observed between the majority of the examiners and the computer measurements. Thus, it can be said that there is a general consensus about the effect of the laugh line on esthetic perception. In the planning of treatment, it is recommended that the laugh line be designed in such a way that 3/4 of the upper incisors be visible and the gum line limit should be 1–2 mm to ensure a more esthetically pleasing result. The different responses given by some examiners may be related to the perception that a high laugh line creates a cheerful impression in individuals.[41]

Ritter *et al.*[42] stated that the width of the buccal corridor is 1 mm larger in men than women. Thus, the buccal corridor measurement was calculated proportionally in order to avoid this difference. In the literature, there is no consensus on the effect of buccal corridor width on smile attractiveness. Hulsey[43], Ritter *et al.*[42], and Johnson *et al.*[44] argued that the width of the buccal corridor, which they call negative space, does not affect the attractiveness of a smile. Moore *et al.*[45] examined the effects of buccal corridors on the attractiveness of smiles; while smiles with minimal buccal corridors received the most appreciation, those with large buccal corridors were found to be esthetically insufficient. Basaran *et al.*[25] found that a 2% wide smile type was the most esthetically pleasing and a 28% narrow smile type was the least pleasing. Ioi *et al.*[46] reported that while narrow buccal corridors were more popular than wide ones, the esthetic acceptability limit was 10–15% of the buccal corridor width. When the results of the present study were examined, it was seen that there was agreement between the computer measurements and the evaluations of the majority of the examiners. When evaluating the buccal corridor width in prosthetic diagnoses and treatments, a satisfactory result can be obtained when the 2–15% width range is taken as a reference. It is recommended that clinicians avoid creating a very wide or very narrow buccal corridor when finishing treatment. The reason for the differences of opinion of the examiners who did not comply with the computer measurement results may be due to the same reason reported in studies that emphasized that the buccal corridor does not affect esthetic perception.[42-44]

In the study by Kokich *et al.*[40] orthodontists found that the 4 mm midline deviation was

esthetically unacceptable, while general dentists and laypersons could not distinguish the midline deviation even when it was 4 mm. Springer *et al*.[36] examining the effect of midline deviation on smile esthetics; they found the maximum acceptable midline deviation amount to be 3.2 mm. Ker *et al*.[32] evaluated the degree of esthetic appreciation created by various dentofacial parameters in laypersons; they found that the maximum tolerable deviation was 2.9 mm, but they reported that it was noteworthy that 1/3 of the participants found the 4.3 mm midline deviation to be acceptable. In the present study, the computer measurement results did not match the evaluations of any of the examiners. All the examiners evaluated the midline deviation more critically than the computer and their "non-esthetic" scores were higher than the objective measurements. This shows that professionally trained examiners consider the 4 mm midline deflection to be more critical and they might not find it to be esthetically pleasing. In contrast, in the literature, a lower tolerance threshold in the midline deviations results in more esthetically pleasing results.

While evaluating the relationship between the dentolabial variables and esthetic perception in the literature, visuals are presented to the participants with computer generated changes and the highest scores or esthetically acceptable ranges are reported. In the present study, natural, unmanipulated smile photos of the volunteers were presented to the examiners to obtain their professional views and the results were compared with the values reported in previous studies. It is thought that the present study is a literature review in terms of the dentolabial variables, and that the consistency of the results is compared with the opinions of the physicians who are professionals in their field; thus, this study makes a scientific contribution to the literature because it is one of the few studies that was performed with this method. It is hoped that the obtained results can guide physicians in terms of the external reference points to be determined during the examination and the factors to be considered about the treatment.

CONCLUSIONS

In summary, this study found that:

1. In the evaluation of smile esthetics, it was seen that the gender of the examiners did not make a significant difference in the results.

2. Although not statistically significant, when the numerical values were examined, it was seen that the women's esthetic evaluations were more consistent with the objective measurements than the men's esthetic evaluations. Similarly, specialists gave answers that were more consistent with the objective measurements than the research assistants.

3. No consensus was found between the esthetically objective findings and the subjective views. It is thought that the most accurate diagnosis and treatment results can be achieved when personal opinions are supported by the objective esthetic values accepted in the literature.

4. It is thought that more detailed and comprehensive results can be obtained if a two-stage evaluation is conducted by taking photographs of smiling faces.

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CONFLICTS OF INTEREST STATEMENT

The authors have no conflict of interests.

ÖZ

Amaç: *Bu çalışmanın amacı bazı ölçülebilir dentolabial kriterlerin literatürde kabul edilen değerleri ile hekimlerin subjektif estetik görüşleri arasındaki uyumu değerlendirmektir.* ***Gereç ve Yöntemler:*** *Protetik Diş Tedavisi alanında dört uzman ve dört araştırma görevlisi diş hekimi çalışmada öznel değerlendirici olarak seçildi. 200 gönüllü katılımcıdan sadece ağız bölgesi görünecek şekilde alınan gülümseme fotoğrafları incelendi. Kesici eğimi ve alt dudak paralelliği, kesici eğimi ve alt dudak temas ilişkisi, gülme hattı, bukkal koridor ve interinsizal çizgi ve orta hat değişkenlerinin objektif ölçüm sonuçları ve değerlendiricilerin subjektif değerlendirmeleri*

Cochran Q testi ile karşılaştırıldı. ***Bulgular:*** *Estetik algı sübjektiftir. Kesici eğimi ve alt dudak paralelliği, gülme hattı ve bukkal koridor değişkenlerinde objektif ölçümler ile subjektif görüşler arasında anlamlı bir ilişki bulundu. Erkek ve kadın bireyler arasında, benzer şekilde uzmanlar ve araştırma görevlileri arasında istatistiksel olarak anlamlı bir fark bulunmadı.* ***Sonuçlar:*** *Estetik olarak objektif bulgular ile öznel görüşler arasında fikir birliği yoktur.* ***Anahtar Kelimeler:*** *Dentolabial analizler, estetik, subjektif görüşler, protetik tedavi.*

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Original research

INFLUENCE OF CARIES AND ORAL HEALTH STATUS ON THE PREVALENCE OF DENTAL EROSION IN 7–14-YEAR-OLD-CHILDREN IN SIVAS, TURKEY

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ABSTRACT

Objective: To determine the prevalence of erosion of schoolchildren, and to reveal the relationship between the dental caries, gingival health status, dental plaque levels and dental erosion.

Materials and methods: A cross-sectional analysis was performed on a representative sample of 473 children (aged 7─14 years). The O'Sullivan, Decayed-Missing-Filled (DMF), Plaque, and Gingival indices were used during the examination of the children. The values were evaluated using chi-square test, Tukey's test, and multivariate logistic regression analysis.

Results: Dental erosion was observed in 21.8% of the children. Lesions were mostly observed in the enamel but less than a half of the buccal surface was affected. Erosion was found to be statistically higher in older children (p=0.001). There was no statistically significant relationship between the children's gender and erosion level (p=0.157). A higher level of erosion was observed in children with high DMFT and DMFS values and low dft and dfs values (p<0.05); children with dental erosion had higher plaque and gingival indices (p<0.05).

Conclusion: Though limited to the enamel, the prevalence of erosion was high and was associated with age, dental caries, dental plaque, and gingival inflammation.

Key words: Dental caries, tooth erosion, dental plaque indices.

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INTRODUCTION

It has been reported that biological factors play an important role in determining sensitivity to dental erosion in hard dental tissues.[1] It is known that, given the suitable conditions, the pellicle or dental plaque on the surface of teeth acts as a reservoir for ions that prevent demineralization on the dental surface and promote remineralization, thus reducing tooth erosion sensitivity.[2] The pellicle is assumed to protect against erosion by acting as a diffusion barrier or a selectively permeable membrane that prevents direct contact between acids and the tooth surface; it has been shown that at least its basal structure survives relatively severe acid exposures.[3] In vitro experiments have indeed demonstrated its protective effects after relatively mild acid challenges[4], but to a lesser extent under more severe conditions.[5] In no case, however, was the protection against erosive dissolution complete. An in-situ study showed that consumption of soft drinks for only 20 seconds led to a decrease in surface microhardness even though the pellicle structure survived on the tooth surface.[6]

Hard dental tissue abrasions, especially dental erosion, pose an increasing problem in industrialized societies due to the type of diet and habits preferred by individuals living in these areas. Dental erosion is a chronic, localized, painless, progressive, and irreversible loss of hard dental tissues. In erosion lesions, hard dental tissue undergoes chemical destruction due to exposure to acids in the absence of bacteria.[7]

Dental erosion may affect both primary and permanent teeth. If the source of erosion that occurs in primary teeth is not found, and necessary precautions are not taken, erosion formation in permanent teeth will be inevitable. Additionally, because the pulp is broad in young permanent teeth, erosion-related pulp inflammation and exposure may occur.[8] For these reasons, it is important to diagnose dental erosion in children at early stages and take protective measures in order to prevent permanent teeth from being affected by erosion.

Increased consumption of acidic foods and drinks today due to changes in lifestyle and diets has increased the incidence of erosion.[9] Increased prevalence of dental erosion has led to an increase in the number of studies on this topic.[10]

Previous studies have shown that the etiology of erosion is multi-factorial and substantially affected by clinical issues (dental plaque and caries), behavioral factors (dietary habits and oral hygiene habits), systemic diseases (gastroesophageal reflux disease, asthma), and demographic and socioeconomic factors.[11-14] It is known that factors such as the type of acid contained in foods and drinks, forms of consumption and pH values affect the erosive potential of such foods and drinks. The sensitivity levels of individuals to erosion may also differ and it is believed that saliva has a significant effect on the formation and severity of caries in addition to erosion. Due to the sugar content and acidic nature of carbonated drinks, caries and erosion may be expected to occur simultaneously.[2]

Hence, the purpose of this study was to determine the prevalence of dental erosion of children aged 7 to 14 years, to learn about the dental caries, gingival health status, and dental plaque levels of the children included in the study, and to reveal the relationship between these parameters and dental erosion, and this way, contribute to protective-preventive practices.

MATERIALS AND METHODS

Obtaining Ethics Committee Approval and Required Permissions

The ethics committee report required for our study was obtained from the Clinical Research Ethics Committee of Cumhuriyet University (ID: 2017-09/03). The official permissions required for the study were obtained from the Research Planning Board of the Sivas Provincial Directorate of National Education.

Sample Selection and Sample Size Calculation

This study was a cross-sectional analysis of children aged 7–14 years, who were studying in different primary and secondary school schools in the provincial center of Sivas, selected through the convenience sampling method.

Out of 44,024 students aged 7–14 years in the provincial center of Sivas, a total of 473 participants (209 primary school students; 264 secondary school

students) were included in the study using the following formula (α=0.05, d=±0.05, p=0.30, q=0.70, t=1.96 / n=[N.t^2.p.q] / [(N-1).d^2 + t^2.p.q]).

Eleven schools — six primary schools and five secondary schools—representing 20% of the schools, were selected using the cluster sampling method. We determined how many students would be taken from each school by using the proportional selection method in the stratified sampling method. Individuals who were receiving orthodontic treatment, those with neurological/psychological problems, individuals using dental prostheses, individuals with communication problems, and individuals who had previously been treated for dental erosion were not included in the study.

Calibration of the Surveyor

Measurements were performed by the researcher E.T. during dental examinations. Calibration of the surveyor was ensured by an expert pedodontist (A.K.) who had experience in dental erosion in the Department of Pediatric Dentistry, Faculty of Dentistry, Cumhuriyet University. The calibration of the surveyor was first carried out on a photograph before the start of the study, and subsequently on 50 children aged 7–14 who presented to the pediatric dentistry clinic.

Distribution of the Informed Consent Forms

The schools where intraoral examinations would be performed were visited one day prior to the examination days. In cooperation with the school administration, each student was given an informed consent form to be sent to the family of the student. On the visit day of the examinations, the children who brought a signed consent form from their legal guardian were included in the study.

Conducting Intraoral Examinations

The study was conducted between October 2018 and December 2018. The children were orally examined in the school building in a room consisting of a table and a chair in the students' own classes. Examination sets (each consisting of a sterilized mouth mirror, a probe, and a dental tweezer), disposable cotton rolls, gloves, face masks, and an examination light pen (Varta Led Pen Light, Dischingen, Germany) held by the researcher were used during the examinations. The examinations were carried out under the illumination of a light pen in detail in terms of dental erosions and dental cavities by cleaning and drying all tooth surfaces with the help of cotton rolls after the children were examined in terms of dental plaques and gingival health. The examination results were obtained by using the O'Sullivan Index[15] (Table 1) for dental erosion, the Decayed-Missing-Filled (DMF) Index (based on the WHO caries criteria for cavities)[16], the Plaque Index (PI) for dental plaques (PI)[17] (Table 2), and the Gingival Index (GI)[18] (Table 2) for gingival inflammation, and these findings were recorded on an examination form.

After completion of the examinations, the students received oral hygiene training and advice on dietary regulation and protection from dental erosion. Dental treatment needs of the children included in the study were determined and reported to their parents in writing after intraoral examinations of the children were performed.

Table 1: O'Sullivan (2000) index.[15]

Site of erosion on each tooth represented by an alphabet	
Code A	Labial only
Code B	Palatal only
Code C	Incisal/occlusal only
Code D	Labial and incisal/occlusal
Code E	Palatal and incisal/occlusal
Code F	Multi-surface
Grade of severity denoted by a number (worst score for any individual tooth recorded)	
Code 0	Normal enamel
Code 1	Matt appearance of the enamel surface with no loss of contour
Code 2	Loss of enamel only
Code 3	Loss of enamel with exposure of dentin (ADJ visible)
Code 4	Loss of enamel and dentin beyond ADJ
Code 5	Loss of enamel and dentine with exposure of pulp
Code 9	Unable to assess (e.g. tooth crowned or large restoration)
Area of surface affected by erosion (denoted by a +/- sign)	
Code -	Less than half of the surface affected
Code +	More than half of the surface affected

Table 2. Plaque index[15] (PI) (Silness and Löe) and Gingival index[16] (GI) (Löe and Silness).

Plaque index		Gingival index	
0	No plaque	0	No swelling
1	Thin visible plaque, difficult to identify	1	Mild swelling, no bleeding after gentle probing
2	Thick visible plaque, easily detected	2	Moderate to severe gingival swelling, bleeding after air drying
3	Presence of plaque filling the interproximal region	3	Severe inflammation; redness and edema. Ulceration. Spontaneous bleeding tendency

After completion of the examinations, the students received oral hygiene training and advice on dietary regulation and protection from dental erosion. Dental treatment needs of the children included in the study were determined and reported to their parents in writing after intraoral examinations of the children were performed.

Statistical Analysis

The data collected in our study were analyzed with the SPSS 22.0 software (version 24.0; SPSS, Inc., Chicago, IL, USA). The Kolmogorov-Smirnov test was used to test the normal distribution of the data. The analysis involved independent-samples Tukey's test (relationships between 'DMFT, DMFS, dfs and dft' and 'gender and dental erosion' and between age and dental erosion) and chi-squared test in 2x2 and nxm crosstabulations in an analysis of data obtained by counting (relationships between 'gingival index and plaque index' and 'gender and dental erosion'). Our data are shown in the tables as arithmetic means, standard deviations, and numbers and percentages of individuals. The percentage of error was considered to be 0.05.

RESULTS

The study included 473 schoolchildren (245 females and 228 males) aged 7-14 years old (mean: 10.16±2.04). Out of the 473 participants, 103 (21.8%) were found to have dental erosions. A total of 329 teeth of the 103 students who were found to have dental erosion were affected by erosion. Out of these 329 teeth, 312 (94.8%) were permanent teeth, whereas 17 (5.2%) were primary teeth. Some of the teeth (11.6%) were found in the mandible, whereas most of them (88.4%) were found in the maxilla (Table 3).

Table 3. The distribution of teeth detected in dental erosion.

	Maxilla n/(%)	*Mandibular n/(%)*	*Total n/(%)*
Permanent teeth	279 (84.7)	33 (10.1)	**312 (94.8)**
Primary teeth	12 (3.7)	5 (1.5)	**17 (5.2)**
Total	**291 (88.4)**	**38 (11.6)**	**329 (100.0)**

The teeth most frequently affected by dental erosion were the teeth numbered 21, 11, 22, and 12 (listed in descending order of frequency). Among the primary teeth, the teeth most frequently affected were numbered 63 and 53. The erosion score most frequently recorded was A1(-), which was found in 47.4% of the total eroded teeth, followed by A2(-), A1(+), and C1(-) in descending order of frequency (Table 4). The teeth surfaces that were affected the most by erosion were the labial and buccal surfaces, and when the severity of erosion on the affected surfaces was examined, the most frequently observed code was "matte appearance of the enamel surface with no loss of contour."

Table 4. Determined dental erosion scores.

Kod	N	%	Site of erosion
A1(-)	156	47.4	
A1(+)	24	7.3	
A2(-)	38	11.6	Labial or buccal only (67.5%)
A2(+)	2	0.6	
A3(-)	2	0.6	
B1(-)	4	1.2	Lingual or palatal only (1.2%)
C1(-)	24	7.3	
C1(+)	8	2.4	
C2(-)	7	2.1	Occlusal or incisal only (13.3%)
C2(+)	2	0.6	
C3(-)	3	0.9	
D1(-)	21	6.4	
D1(+)	14	4.3	Labial and incisal/occlusal (15.6%)
D2(-)	14	4.3	
D2(+)	2	0.6	
F1(-)	4	1.2	
F1(+)	1	0.3	Multisurface (2.4%)
F2(+)	3	0.9	
Total	329	100.0	
Code	**N**	**%**	**Grade of severity of erosion**
Code 1	256	77.8	Matt appearance of the enamel surface
Code 2	68	20.7	Loss of enamel only
Code 3	5	1.5	Loss of enamel with exposure of dentin
Total	329	100.0	
Code	**N**	**%**	**Area of surface affected by erosion**
Code -	273	83.0	Less than half of the surface affected
Code +	56	17.0	More than half of the surface affected
Total	329	100.0	

The prevalence of erosion among the children was 19.2% of the female children and 24.6% of the male children, but the difference was not statistically significant (p=0.157) (Table 5).

Table 5. Association of gender and plaque index, gingival index with erosion.

Variables	*Erosion present n/(%)*	*Erosion absent n/(%)*	*Total n*	
Gender				
Famale	47 (19.2)	198 (80.8)	245	X^2=2.00
Male	56 (24.6)	172 (75.4)	228	p=0.157
Plaque index				
Score 0	13 (13.0)[a]	87 (87.0)	100	X^2=6.15
Score 1	79 (23.7)[b]	255 (76.3)	334	p=0.046*
Score 2-3	11 (28.2)[b]	28 (71.8)	39	
Gingival index				
Score 0	18 (12.9)[a]	121 (87.1)	139	X^2= 9.45
Score 1	81 (25.2)[b]	241 (74.8)	322	p=0.009*
Score 2	4 (33.3)[b]	8 (66.7)	12	

†Different small letters indicate statistically significance within each column.
‡ p <0.05 statistically significant.

The mean age of the children who had dental erosion was statistically significantly higher than the mean age of those who did not have dental erosion (p=0.001) (Table 6).

Table 6. Association of tooth erosion with mean age, DMFT, DMFS, dft, dfs.

	n	*Mean age*	*Std. deviasyon*	
Erosion present	103	10.73	2.01	t=3.27
Erosion absent	370	10.00	2.02	p=0.001*
	n	Mean DMFT	Std. deviasyon	
Erosion present	103	1.50	1.86	t=2.29
Erosion absent	370	1.09	1.51	p=0.022*
	n	Mean DMFS	Std. deviasyon	
Erosion present	103	2.04	2.72	t=2.05
Erosion absent	370	1.49	2.28	p=0.043*
	n	Mean dft	Std. deviasyon	
Erosion present	103	1.61	2.30	t=2.55
Erosion absent	370	2.27	2.57	p=0.019*
	n	Mean dfs	Std. deviasyon	
Erosion present	103	2.27	3.24	t=3.07
Erosion absent	370	3.44	3.92	p=0.002*

†p <0.05 statistically significant.

The participants had a mean DMFT value of 1.18±1.60 and a mean DMFS value of 1.61±2.39, whereas the mean dft and dfs values of those in their mixed dentition period were 2.13±2.52 and 3.18±3.81 respectively. There was no significant relationship between the gender of the participants and their DMFT, DMFS, dft, or dfs values (p>0.05) (Table 7).

Table 7. Association of gender with mean DMFT, DMFS, dft, dfs.

Gender	*n*	*Mean DMFT*	*Std. deviasyon*	
Famale	245	1.20	1.68	t=0.40
Male	228	1.14	1.51	p=0.688
	n	Mean DMFS	Std. deviasyon	
Famale	245	1.58	2.40	t=0.31
Male	228	1.65	2.39	p=0.759
	n	Mean dft	Std. deviasyon	
Famale	245	2.25	2.58	t=1.09
Male	228	2.00	2.47	p=0.476
	n	Mean dfs	Std. deviasyon	
Famale	245	3.37	3.86	t=1.08
Male	228	2.99	3.76	p=0.279

In terms of their DMFT and DMFS values, there was a significant difference between the participants who had dental erosion and those who did not. There were statistically significantly higher DMFT and DMFS values among the participants who had dental erosion (p<0.05) (Table 6).

There was also a statistically significant difference between the participants who had dental erosion and those who did not have dental erosion in terms of their dft and dfs values (p<0.05). Those who had dental erosion had significantly lower dft and dfs values (p<0.05) (Table 6).

In the analysis of the relationship between dental erosion and dental plaque index scores, among the 103 participants who had dental erosions, the PI score was 0 (no plaque) in 13 participants (13.0%), 1 (separate flecks of plaque at the cervical margin of tooth) in 79 (23.7%), 2 (thin continuous band of plaque) in 10 (28.2%), and 3 (band of plaque wider than 1 mm but covering less than 1/3 of the crown) in 1 (<1%). The score of 1, and score of 2-3 were statistically significantly more frequent than the score of 0 among the participants who were found to have dental erosions (p<0.05). However, the difference between the prevalence of the score of 1 and the

scores of 2-3 was not statistically significant (p>0.05) (Table 5).

In the analysis of the relationship between dental erosion and gingival index scores, among the 103 who had dental erosions, the GI score was 0 (no inflammation) in 18 participants (12.9%), 1 (mild inflammation) in 81 (25.2%), and 2 (moderate inflammation) in 4 (33.3%), whereas no score of 3 (severe inflammation) was recorded in any of the participants. The scores of 1 and 2 were statistically significantly more frequent than the score of 0 among the participants who had dental erosions p<0.05). However, the difference between the prevalence of the scores of 1 and 2 was not statistically significant (p>0.05) (Table 5).

In the analysis of the relationship between gender and plaque index scores, there was no significant difference between the genders in terms of the frequencies of their scores of 0 or 1, whereas the scores of 2-3 were observed statistically significantly more frequently among the male children (p=0.008) (Table 8). In contrast, no statistically significant difference was found between the male and female children in terms of their gingival index scores (p=0.103) (Table 8).

Table 8. Association of gender with plaque index, gingival index.

Variables	*Famale n/(%)*	*Male n/(%)*	*Total n*	
Plaque index				
Score 0	55 (55.0)[a]	45 (45.0)[a]	100	X^2=9.53
Score 1	179 (53.6)[a]	155 (46.4)[a]	334	p=0.008*
Score 2-3	11 (28.2)[b]	28 (71.8)[c]	39	
Gingival index				
Score 0	81 (58.3)	58 (41.7)	139	X^2= 4.54
Score 1	160 (49.7)	162 (50.3)	322	p=0.103
Score 2	4 (33.3)	8 (66.7)	12	

†Different small letters indicate statistically significance within each column.
‡ p <0.05 statistically significant.

DISCUSSION

Nutritional and oral hygiene habits of children were not included in the study because the purpose of this study was to determine the prevalence of erosion of schoolchildren, and to reveal the relationship between the dental caries, gingival health status, dental plaque levels and dental erosion. This was the limitation of the study.

The development of the food and drinks industries has caused carbonated and acidic drinks to be increasingly supplied in the market and be consumed more frequently especially by children. This issue is considered to increase the prevalence and severity of tooth abrasion due to acidic factors, eventually leading to dental erosion.[19] Studies have determined that erosion formation today is rapidly becoming more prevalent.[20,21] Determination of the etiological factors of dental erosion is at the top of the preventive measures utilized by dentists.[22] Classification of the degree of erosion severity observed in an individual reveals the erosive factor the individual has been exposed to, as well as determines the protective measures to be employed. This is crucial for finding a solution for the existing problem and engaging in protective-preventive practices against erosions that may form later.[23]

For protection against erosion and for effective diagnosis, it is vital to utilize an index that is easy to use, can be used to evaluate both primary and permanent teeth, and may be easily replicable under different conditions. In the present study, we used the O'Sullivan index[15] which assesses the location, severity and affected surface area of dental erosion, and reflects even small changes in dental erosion; we believe it provides more detailed information than other indices in the literature.

In a study, the age group being analyzed may affect the prevalence of the dental erosion recorded. This study included children aged 7 to 14 years. As the probability of the teeth to be affected by attrition or abrasion is low in this age

group, it is easier to diagnose dental erosion. Additionally, acidic variables may sufficiently affect the teeth in the age group we selected.[24] Epidemiological studies conducted in different parts of the world analyzed similar age groups as well.[25-27] In this study, the age group of 7-14 years was selected to enable us to draw a parallel in the analysis of the prevalence of dental erosion and to compare our results to those of studies carried out in different countries.

In our study, 21.8% of the participants had dental erosion in at least one tooth; this is similar to the results of some previous studies.[12,28] There are also higher[29,30] and lower[11,31,32] results reported in the literature. The broad range of the prevalence of dental erosion may be attributed to several variables such as the type of index used to diagnose erosion, the sample size, inclusion criteria, age group, and the teeth that were examined.

According to the results of our study, among the 103 (21.8% of the sample population) participants found to have dental erosions in their permanent and mixed dentition periods, 329 teeth were affected by erosion. Out of these 329 teeth, 94.8% consisted of permanent teeth, while 5.2% consisted of primary teeth. Çağlar *et al.*[26] also reported a lower rate of erosion in primary dentition in their study, which examined both primary and permanent teeth; however, most studies in the available literature reported higher rates of erosion in primary teeth. Though previous studies found primary teeth to be more prone erosion due to their structural properties, in our study, the prevalence of erosion among the participants was examined as a whole without dividing the participants into primary and permanent dentition groups. Nevertheless, primary teeth were found to have a lower prevalence of erosion when the findings for primary and permanent teeth were assessed separately.

In this study the most frequently encountered erosion score was A1(-), the buccal surface was affected the most[11,12,31,33], the erosion was mostly limited to the enamel[11,25,28,31,32] and mostly less than half of the surface was affected by erosion[11, 31-33]; these result are similar to those of previous studies. From our observation, extrinsically encountered acids were mostly the causative agents of the erosion lesions we found in the participants; this inference was based on the assessment of the distances of the teeth to major and minor salivary gland openings as erosion was mostly found on the buccal surfaces of maxillary incisor teeth, which have a low rate of cleansing by saliva. Our observation that the erosion lesions detected in our study occurred without loss of contour in the enamel and in less than half of the surface may suggest that the severity of erosion was low and that the participants who had dental erosions in our study were exposed to erosive factors for a short time or constantly on low levels.

In our study, the prevalence of erosion was higher in male children, although the difference in prevalence between the male and female children was not statistically significant (24.6% in males, 19.2% in females). There are studies in the available literature that similarly found no significant difference between female and male patients in terms of prevalence of erosion.[11,12,32,34]

According to the results of our study, the mean age of the participants who had dental erosions was significantly higher than the mean age of those who did not have dental erosions. Similarly, Zhang *et.al.*[35] and Salas *et.al.*[25], reported that the prevalence of dental erosion was higher with increased age in their studies. This relationship between age and prevalence of erosion may be explained by the fact that dental erosion has a tendency to progress and is essentially a case of prolonged exposure to erosive factors.[21,36]

Dental caries and dental erosion are dental pathologies that are characterized by demineralization of hard dental tissues because of acid attacks.[37] An interesting point on the relationship between dental erosion and caries is the assumption that an acidic oral environment may increase the likelihood of caries in an individual by promoting the growth of

Streptococcus mutans (S.mutans), which is an acidophilic species of bacteria. There are studies in the available literature that examined the etiological factors of dental erosion and supported the assumption that children who have dental erosion have high numbers of S. mutans in their oral cavity.[1,38]

In our study, the participants with higher DMFT and DMFS values were found to have a significantly higher prevalence of dental erosion. Although this may be explained by the fact that the salivary characteristics of individuals with dental erosion and those with active caries are similar[39] and that such individuals also consume acidic beverages that contain more sugar (which is a risk factor for both dental erosion and cavities), we believe that teeth that are already structurally weakened by cavities may be easily affected by erosive factors. The results of studies in the available literature that showed a positive relationship between dental erosion and cavities corroborate our results.[33,34,38]

In our study, participants with higher dft and dfs values were found to have a significantly lower prevalence of dental erosion. It is believed that such a result emerged because of the finding that dft and dfs values, which are used to diagnose cavities in primary teeth, tend to be higher in younger age groups, who presented lower erosion rates in our study.

It is known that dental plaque serves as a reservoir for ions that prevent demineralization on dental surfaces and promote remineralization under suitable conditions.[2] In a study that investigated the progression of dental erosion with a follow-up time of four years, Hasselkvist *et al.*[40] determined that there was a higher prevalence of dental erosion in individuals with low plaque and gingival indices whereas Mantonanaki *et al.*[33], reported that children with low mean dental plaque scores had significantly higher rates of dental erosion. As opposed to the results of previous studies, the plaque index and gingival index scores were significantly higher among the children who had dental erosion in our study. The composition, thickness, and maturation time of dental plaque determines its level of protection against erosion. As dental plaque was most frequently seen near the gingival margin as a thin plaque (Score: 1) in our study, we believe it could not provide sufficient protection against acid attacks. Furthermore, studies have demonstrated that plaque can protect the tooth against demineralization to a certain extent in the case of acid attacks. Although it was found that dental plaque has a potential to reduce the level of demineralization in the enamel in the case of exposure to acid, it cannot completely prevent acid-related changes.[41] We believe that the protective effect of the plaque may have been rendered insignificant due to high levels of consumption of acidic drinks by the participants.

CONCLUSIONS

According to the findings of our study, there is a relationship between dental erosion and the parameters of dental caries, dental plaque levels, and gingival health. Although studying the risk factors for dental erosion as well as questioning the daily activities and personal dietary habits of patients is important, it is also vital to obtain information about their oral hygiene habits. On early diagnosis of dental erosion, individuals should be counseled on the improvement of oral hygiene and protective measures should be taken to minimize the risk of further erosion for the individual.

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CONFLICTS OF INTEREST STATEMENT

There is no conflict of interest.

Türkiye, Sivas İlinde Yaşayan 7–14 Yaşlarındaki Çocuklarda Çürük ve Ağız Sağlığı Durumunun Dental Erozyon Prevalansına Etkisi

ÖZ

Amaç: *Okul çocuklarında erozyon prevalansını belirlemek ve diş çürüğü, dişeti sağlığı durumları, diş plağı düzeyleri ve diş erozyonu arasındaki ilişkiyi ortaya koymaktır.* ***Gereç ve Yöntem:*** *473 çocuğun (7-14 yaş) temsili bir örneği üzerinde kesitsel analiz*

yapıldı. Çocukların muayenesinde O'Sullivan, Çürük-Eksik-Dolgulu (DMF), Plak ve Dişeti indeksleri kullanıldı. Elde edilen veriler ki-kare testi, Tukey testi ve çok değişkenli lojistik regresyon analizi kullanılarak değerlendirildi. ***Bulgular:*** *Çocukların %21,8'inde dental erozyon gözlendi. Lezyonlar çoğunlukla minede gözlendi, ancak bukkal yüzeyin yarısından azı etkilendi. Büyük çocuklarda erozyon istatistiksel olarak daha yüksek bulundu (p=0,001). Çocukların cinsiyeti ile erozyon arasında istatistiksel olarak anlamlı bir ilişki yoktu (p=0,157). Yüksek DMFT ve DMFS değerleri ile düşük dft ve dfs değerleri olan çocuklarda daha yüksek erozyon seviyesi gözlendi (p<0,05); dental erozyonu olan çocukların plak ve dişeti indeksi daha yüksek bulundu (p<0,05).* ***Sonuç:*** *Mine ile sınırlı olmasına rağmen, erozyon prevalansı yüksektir ve bu durum yaş, diş çürüğü, diş plağı ve dişeti iltihabı ile ilişkilidir.* ***Anahtar kelimeler:*** *Diş çürüğü, diş erozyonu, diş plak indeksi.*

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Original research

A STUDY ON THE USE OF DIFFERENT MATERIALS COMBINED WITH ALLOGRAFT ON OSSEOINTEGRATION AND BONE REGENERATION OF DENTAL IMPLANTS WITH CORONAL DEFECTS IN A RABBIT MODEL

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ABSTRACT

Objectives: To assess differential effects of different materials combined with allograft on bone-to-implant contact and newly formed bone formation in dental implants with coronal defects histomorphometrically.

Materials and Methods: The study was conducted on 24 male New Zealand white rabbits. Dental implants (3.0 × 10 mm) were placed at the center of defects (9 mm diameter, 4 mm depth) created in the tibial bones of the rabbits. Graft (GF, n=8), graft + rifamycin (GR, n=8) and graft + black cumin oil via orogastric route (GB, n=8) were applied on the coronal aspects of the implants for 28 days. Undecalcified histomorphometric analyses were conducted on slides stained with toluidine blue.

Results: Bone-to-implant contact was 46.57% ± 3.59% in the graft (GF), 67.12% ± 3.64% in the graft + rifamycin (GR) and 55.62% ± 4.37% in the graft + black cumin oil (GB) groups. The percentage of new bone formation at the defect area was 34.71% ± 4.11% in the graft, 55.37% ± 4.89% in the graft + rifamycin, and 45.75% ± 3.69% in the graft + black cumin oil groups. In terms of new bone formation and bone-to-implant contact, graft + rifamycin and graft + black cumin oil groups were significantly different from the graft group. The differences between the graft + rifamycin and graft + black cumin oil groups were also statistically significant.

Conclusions: Allograft + rifamycin and orogastric black cumin oil were found to have positive effects on bone healing at sites with coronal defects. Rifamycin showed significantly greater favorable effects on bone-to-implant contact and new bone formation compared to black cumin oil.

Key Words: Allograft, rifamycin, black cumin oil, histomorphometry, dental implant.

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INTRODUCTION

Long-term success has been demonstrated clinically for dental implants used in dentistry and dental implants have become a widely preferred, alternative therapeutic option. Compared to traditional dental prosthesis, patients have reported greater satisfaction and improved quality of life with dental prosthesis supported by dental implants in terms of comfort, stability and esthetics.[1]

While dental implants are the most preferred and effective treatment modality, their effectiveness depends largely on successful osseointegration during the healing process. Branemark *et al.*[3] described osseointegration as the direct structural and functional connection of living bone to load-bearing endosseous implants and several factors are involved in the establishment of such connection. Thus, this is an area that still requires a great deal of further research and development.[2]

Implants can be placed in fresh sockets after tooth extraction using the immediate implant loading method, allowing for shortening of the long healing period. However, this may lead to formation of bone defects resulting from size difference between the implant and the extraction socket.[4]

Several grafting materials are used for peri-implant bone defects. Autogenous bone grafts have osteoinductive, osteoconductive and bone regenerative properties and the use of autogenous bone grafts is the gold standard for repairing bone defects owing to their biocompatibility and rapid revascularization. However, challenges associated with harvesting the autograft, requirement for a second surgical operation, inability to harvest sufficient volumes of autograft and complications such as postoperative pain limit routine use of autogenous bone grafts. Consequently, allografts with osteoinductive and osteoconductive capabilities have been introduced as an alternative to autogenous bone grafts.[5] In osteoconduction, graft material does not activate bone formation but rather serves as a scaffold or physical matrix for new bone growth that is perpetuated by the native bone. At this stage, some bone grafts are reabsorbed and finally disappear completely as new bone formation, but others are not reabsorbed and help healing of the defect by filling the spaces between graft fragments and newly formed bone.[6] Osteoinduction involves the stimulation of osteogenesis mechanism and owing to growth factors and signalling proteins they contain some graft materials exhibit osteoinductive property by stimulating mesenchymal stem cells in the recipient tissue to differentiate into osteoblasts.[7]

Recently, research on filling bone defects has focused on local or systemic substitutes (e.g., antibiotics or platelet-rich plasma) that could possibly promote effectiveness of graft materials in new bone formation.[4,8] Antibiotics have been used for many years in various fields of medicine. Numerous antimicrobials were used to achieve aforementioned purpose including tetracycline, tobramycin, cefalotin, vancomycin, nitrofurazone, rifamycin, povidone iodine and chlorhexidine.[9] More recent studies have increasingly examined the effects of rifamycin on promoting bone formation with overall successful results.[10,11] In a study on experimental animals, Carvalho *et al.*[10] reported that irrigation with rifamycin led to better bone formation in extraction sockets where fibrinolytic alveolitis was produced compared to control group. In one study by Tasdemir *et al.*[11] contaminated autologous onlay bone grafts harvested from experimental animals were decontaminated with rifamycin and reintroduced and histological examination showed earlier revascularization and osteogenesis in the decontamination group compared to control group.

Nigella sativa is an herbaceous annual plant that belongs to the *Ranunculaceae* family which grows from its seeds. The seeds of *N. sativa* are 2-3 mm triangular grains with an intense black color. *N. sativa* seeds contain water, ash, crude protein, crude fiber, and carbohydrates (68%) and a substantial amount of volatile oil (32%). The major active chemical component of the volatile oil is thymoquinone (2-isopropyl-5-methyl-1,4-benzoquinone).[12] Thymoquinone (TQ) was reported to have antihypertensive, hypoglycemic, antifungal, antibacterial, antiallergic as well as immunopotentiating activities.[13,14] TQ also has

anti-inflammatory and antioxidative properties and accelerates new bone formation.[15] Ozdemir *et al*.[16] evaluated the effectiveness of black cumin oil administered by orogastric route on alveolar bone resorption in rats with experimental periodontitis and reported much less alveolar bone loss in the TQ groups versus control group.

Considering these data, we believe that black cumin oil, when given by orogastric route, may accelerate bone formation and promote faster healing and thereby shorten the osseointegration time in the treatment of peri-implant defects using allografts. To our best knowledge, there are no similar studies in literature on treatment of peri-implant bone defects with both rifamycin and black cumin oil. Thus, the aim of the current study was to compare the effects of rifamycin locally administered at the time of grafting and systemic black cumin oil on osseointegration in implants with coronal defects versus control group histomorphometrically.

MATERIAL AND METHODS

The experimental animal group consisted of 24 male New Zealand white rabbits *(Oryctolagus cuniculus L.)* of 6 months of age and weighing 2.5 to 3.5 kg. Rabbits were divided into 3 equal groups to be applied graft (GF, n=8), graft + rifamycin (GR, n=8) and graft + black cumin oil via orogastric route (GB, n=8). Food and water were supplied to the animals without any restriction. Standard rabbit feed was used as forage. Standard conditions (22-24ºC, 55-70% humidity, 1 ATM) were applied for the rabbits in the animal room. During the study, experimental animals were placed into stainless steel cages (50 × 80 × 50 cm) such that there was one animal in each cage. After their transfer to the laboratory, all animals were subjected to one month of treatment and monitoring to ensure optimal health conditions and protection from infections and to allow for adaptation of animals to their new habitat prior to surgical procedures.

Approval for the conduct of the study was obtained from the Animal Experimentation Ethics Committee of Sivas Cumhuriyet University before initiation of the study (date 25.12.2014 and no. 63) and principles of ethical treatment of experimental animals set forth in the Article 13 of the Code of Ethics of Sivas Cumhuriyet University were followed.

Supported by Sivas Cumhuriyet University Scientific Research Projects Unit (CUBAP), the present research study (code no. DIS-158) was conducted at the Experimental Animal Laboratory of Sivas Cumhuriyet University and the Research Laboratory of Erciyes University, Faculty of Dentistry, Department of Oral and Maxillofacial Surgery.

Surgical Procedure

All operations were performed on rabbits under general anesthesia induced by Xylazine (10-20 mg/kg) (Rompun 2%, Bayer, Istanbul, Turkey) and Ketamine HCl (50 mg/kg) (Ketalar, Eczacıbaşı-Warner Lambert, Istanbul, Turkey). Experimental side of the tibia was shaved and cleaned with povidone-iodine. Surgical area was prepared by applying a sterile film on the tibia sections covered with a sterile surgical drape. A skin incision of 2-3 cm was made from the medial proximal metaphysis of the tibia towards the distal. Subcutaneous and muscle layers were crossed by blunt dissection and the surface of the tibia bone was reached. By use of a trephine drill, bony defects (9 mm diameter, 4 mm depth) were created under saline solution irrigation. (Figure 1)

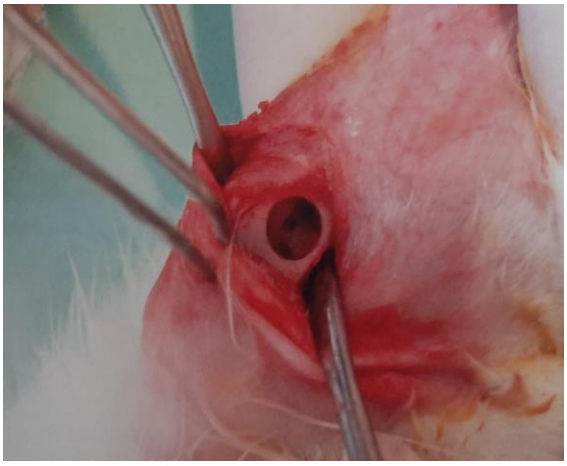


Figure 1. Bone defect created on tibia with trepine drill.

Implant beds (3 mm diameter, 6 mm depth) were prepared in the center of each defect according to the manual of the implant system. (Figure 2)

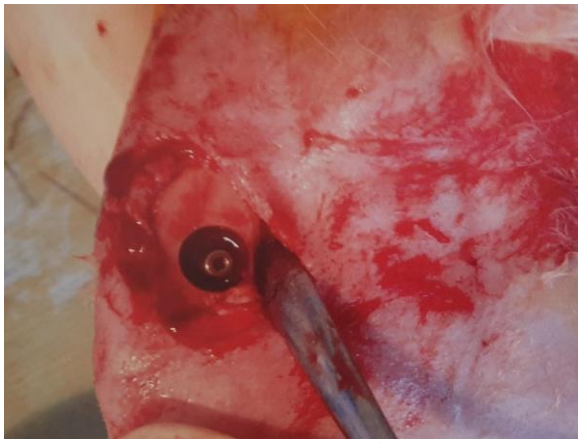


Figure 2. Dental implant placed in bone defect

After drilling, the implant beds were rinsed with saline solution, and implants (Touareg-NP, 3.0x10 mm; Adin Dental Implant System, Afula, Israel) were inserted with primary stability (6-mm depth). The upper part of the implant was free (4 mm depth) at the center of the created defects. Healing caps were screwed on the exposed portion of the implants. In all groups, an allograft (Maxxeus Community Tissue Services, Ohio, USA) was used for the coronal part. GF group received graft alone, while GR group received graft + rifamycin (RİF, Koçak Farma, Istanbul, Turkey). Black cumin oil (2 mg/kg daily) was administered by gastric feeding until the animals were killed on day 28.

After the surgery, muscle and subcutaneous fascia were sutured in the elevated epidermal flaps. The tissues were sutured in 2 layers using degradable sutures (Pegelak, poly [glycolide-co-lactide]; Dogsan, Trabzon, Turkey). 50 mg/kg Ceftriaxone (Cephaxon; Toprak, Istanbul, Turkey) IM and Carprofen, 4 mg/kg SC (Rimadyl; Pfizer, New York, NY) were given once daily for three days to experimental animals postoperatively. Animals were sacrificed at 4 weeks after implantation. The implants with surrounding bones were dissected, and any signs of unusual healing were documented.

Preparation of Histological Sections and Histomorphometric Examination

Bones surrounding the implants were removed along with 1 cm-wide intact bone and then stored in 4% buffered formalin solution for 24 hours. Subsequently, specimens were dehydrated with 60%, 80%, 96%, and 100% ethanol in alcohol tanks for one day. Dehydration of specimens in an ascending series of ethanol rinses was followed by embedding in a methyl methacrylate-based resin (Technovit 7200 VLC; Kulzer and Co, Wehrheim, Germany). These blocks were subjected to light polymerization over 8 hours at 40°C under a wavelenGBh of 450 nm and then adhered on plexiglass slides under vacuum.

300-350 μm thick sections were obtained from the specimens using a high-precision diamond disk saw (Exakt 300 CL, Exakt Apparatebau, Germany). Then, sections were ground down to 40 μm using abrasive papers from a microgrinding system (Exakt 400 CS, Exakt Apparatebau, Norderstedt, Germany), and four sections were prepared from each specimen and stained with toluidine blue.

For histomorphometric evaluation, all sections were visualized by a light microscope (Olympus® CX41, Tokyo, Japan) and a digital camera mounted on the microscope (Olympus® DP 25, Tokyo, Japan). Images were downloaded to a personal computer and analyzed histomorphometrically using a Bioquant Osteo II image analysis software (Bioquant Image Analysis Corp., Nashville, TN).

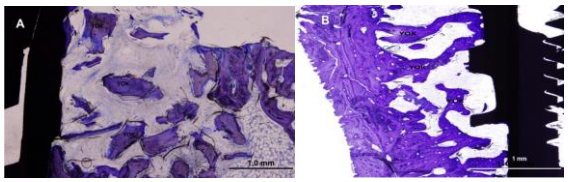
The percentage of bone-to-implant contact (BIC) was calculated from the implant shoulder to the end of the gap (4 mm) and new bone formation on each section was expressed as a percentage of bone volume.

Statistical Analysis

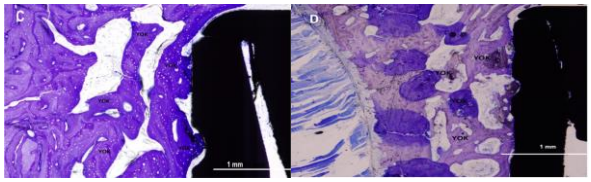
The data of the study were loaded into SPSS program (version 14.0 for Windows) and normal distribution was determined by Kolmogorov-Smirnov test in the evaluation of the data. The differences between the groups were evaluated by parametric test, ANOVA variance analysis test. Significant differences were determined according to test results. Tukey test, one of the post-hoc tests, was used to determine the cause of this difference. The data were expressed as arithmetic mean ± standard deviation in the tables and p value was taken as 0.05.

RESULTS

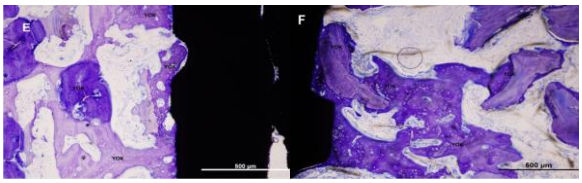
Rabbits had no weight loss after surgery. Following a 28-day period of non-problematic healing, successful osseointegration was achieved in all implants. New bone formation was present in peri-implants in all groups. (Figure 3)



A-B= Group receiving only allograft after 28 days of surgery.



C-D= Group receiving allograft mixed with rifamycin after 28 days of surgery.



E-F= Group receiving allograft and orogastric feeding with black cumin oil for 28 days. Toluidine blue staining shows new bone formation around dental implant.

Figure 3. Histologic evaluation of experimental defect area (toluidine blue stain, with scale bar equal to 1 mm and 500 μm)

Bone-to-implant contact was 46.57%±3.59% in the graft (GF), 67.12% ± 3.64% in the graft + rifamycin (GR) and 55.62%±4.37% in the graft + black cumin oil (GB) groups. The percentage of new bone formation at the defect area was 34.71%±4.11% in the graft, 55.37% ± 4.89% in the graft + rifamycin, and 45.75% ± 3.69% in the graft + black cumin oil groups (Table 1).

Table 1. Percentage of direct bone-to-implant and new bone formation at the defect area.

Groups	BIC*	New Bone Formation
Graft (GF), %	46.57 ± 3.59	34.71 ± 4.11
Graft+Rifamycin (GR), %	67.12 ± 3.64	55.37 ± 4.89
Graft+ Thymoquinone (GT), %	55.62 ± 4.37	45.75 ± 3.69

Note: Data are presented as mean (standard deviation).
Abbreviations: BIC, bone-to-implant contact.
Statistically significant difference ($p < 0.05$) between graft (GC) and graft plus rifamycin (GR) for BIC.
Statistically significant difference ($p < 0.05$) between graft (GC) and graft plus black cumin oil (GT) for BIC.
Statistically significant difference ($p <0.05$) between graft plus rifamycin (GR) and graft plus black cumin oil (GT) for BIC.
Statistically significant difference ($p < 0.05$) between graft (GC) and graft plus rifamycin (GR) for new bone formation.
Statistically significant difference ($p <0.05$) between graft (GC) and graft plus black cumin oil (GT) for new bone formation.
Statistically significant difference ($p < 0.05$) between graft plus rifamycin (GR) and graft plus black cumin oil (GT) for new bone formation.

The percent (%) difference in new bone formation between groups was significant ($p<0.05$), with greatest new bone formation in the group treated with rifamycin (GR) and least new bone formation in the group receiving graft alone (GF). Percent BIC also significantly different between groups ($p<0.05$) with the highest percentage observed in the group receiving rifamycin, followed by black cumin oil (GB) and control (GF) groups ($p<0.05$) (Table 2).

Table 2. Statistical significance of groups

	GF-GR	GF-GB	GR-GB
BIC	p<0.05	p<0.05	p<0.05
NBF	p<0.05	p<0.05	p<0.05

BIC= Bone-to-implant contact
NBF= New bone formation
GF= Graft
GR= Graft+Rifamycin
GB= Graft+ Orogastric black cumin oil

DISCUSSION

Many conventional methods used for rehabilitation of edentulous patients have been replaced by therapeutic interventions involving dental implants which are now increasingly popular.[17] The major factor that influences the overall success of a dental implant is to achieve and maintain osseointegration.[18]

In human studies, small gaps (less than 2 mm) around the implant were reported to heal spontaneously without the need to use allograft, xenograft or membranes.[19,20] A critical-size defect is an intraosseous wound in a particular bone and species of animal that will not heal spontaneously morphologically and functionally during the lifetime of the animal. During healing, large bone defects are filled with fibrous connective tissue rather than bone tissue.[21] In a relevant study, 8-mm defect was produced, and healing was assessed histologically. With bone healing, the defect area reduced in size to 5-mm but healed by formation of fibrous connective tissue at the core of the defect.[22] However, in the present study, osseointegration was achieved in our experimental 9-mm defects that were healed with allografts without formation of fibrous tissue.

Beneficial results were reported by several studies in the reconstruction of peri-implant bone defects with grafting.[23,24] Additionally, there are some studies which used combinations of graft materials with various agents with the aim to enhance osteogenesis.[8] Differential results were reported by studies that combined rifamycin with allografts. Witso *et al*.[25] showed that allograft in combination with rifamycin or other antibiotics reduced bacterial contamination and promoted osteogenesis. In a separate study, Simsek *et al*.[8] produced 9-mm bone defects in rabbit tibias and treated control group with allograft plus saline solution and experimental groups with allograft plus platelet-rich fibrin (PRF) or allograft + rifamycin. As result, the group treated with rifamycin plus allograft showed inferior results compared to PRF group, but significantly greater BIC and new bone formation compared to control group. Contrastingly, Kaya *et al*.[26] examined osteogenesis following administration of rifamycin in combination with allogeneic, alloplastic, and heterogeneous grafts to bone defects created in rat tibias. They reported that rifamycin could reduce new bone formation when combined with allograft in bone defects. However, our current findings support prior successful results obtained with rifamycin.

Culturing studies are available in literature that investigated the effects of rifamycin on human osteoblast-like cells. In these studies, rifamycin was shown to have toxic or inhibitory effects on osteoblast-like cells when used at concentrations exceeding a certain threshold.[27,28,29]

While black cumin oil is well known for its various beneficial effects against several diseases[14], its detailed effects on bone formation were examined in few studies. Wirries *et al*.[30] reported a significant impact of TQ on proliferation, differentiation, and mineralization of cultured osteoblast cells. Kara *et al*.[31] looked at the effects of TQ systemically administered during rapid maxillary expansion procedure on the bone formation and reported a considerable increase in new bone formation in the group treated with TQ compared with other groups.

A healing period of 28 days was used in the present study for recovery of peri-implant bone defects.[8] Although the current study demonstrated that rifamycin and black cumin oil can increase and/or accelerate bone formation, it was not possible to establish all potential effects in such a short period of time. Thus, further long-term studies are needed to examine the effects of rifamycin and black cumin oil on bone healing.

The current study supports the hypothesis that rifamycin and black cumin oil might promote and accelerate bone formation in peri-implant bone defects when used in combination with allografts.

CONCLUSION

The use of various materials in conjunction with allograft can speed up new bone formation and bone-implant contact. Especially in this study conducted to investigate the materials that increase the success of grafting with immediate loading, it was observed that the use of rifamycin and black cumin oil had a positive effect in the early period of osseointegration. Rifamycin gave better results than other materials. Long-term effects of these materials should be examined in further studies.

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CONFLICTS OF INTEREST STATEMENT

The authors report no conflicts of interest.

Koronal Defektli Dental İmplantların Osseointegrasyon ve Kemik Rejenerasyonunun Allogreft ile Birlikte Farklı Rejenerasyon Tekniklerinin Kullanımı

ÖZ

Amaç: *Allogreft ile kombine edilen farklı materyallerin kemik-implant teması ve koronal defektleri olan dental implantlarda yeni oluşan kemik oluşumu üzerindeki farklı etkilerini histomorfometrik olarak değerlendirmektir.* ***Gereç ve Yöntemler:*** *Çalışma 24 erkek Yeni Zelanda beyaz tavşanı üzerinde gerçekleştirildi. Dental implantlar (3.0×10 mm), tavşanların tibial kemiklerinde oluşturulan defektlerin merkezine (9 mm çap, 4 mm derinlik) yerleştirildi. İmplantların koronal kısımlarına 28 gün boyunca greft (GF, n=8), greft+rifamisin (GR, n=8) ve greft+orogastrik yoldan çörekotu yağı (GB, n=8) uygulandı. Toluidin mavisi ile boyanmış kesitler üzerinde dekalsifiye edimemiş histomorfometrik analizler yapılmıştır.* ***Bulgular:*** *Kemik-implant teması greftte %46.57±%3,59, greft+rifamisin %67,12±%3,64 ve greft+ çörekotu yağı gruplarında %55,62±%4,37 idi. Defekt alanındaki yeni kemik oluşumu yüzdesi greftte %34,71±%4,11, greft + rifamisinde %55,37±%4,89 ve greft+ çörekotu yağı gruplarında %45,75±%3,69 idi. Yeni kemik oluşumu ve kemik-implant teması açısından greft+rifamisin ve greft+çörekotu yağı grupları greft grubundan anlamlı olarak farklıydı. Greft+rifamisin ve greft+çörekotu yağı grupları arasındaki farklar da istatistiksel olarak anlamlıydı.* ***Sonuçlar:*** *Allogreft+ rifamisin ve orogastrik çörekotu yağının koronal defektli bölgelerde kemik iyileşmesi üzerinde olumlu etkileri olduğu bulunmuştur. Rifamisin, çörekotu yağına kıyasla kemik-implant teması ve yeni kemik oluşumu üzerinde önemli ölçüde daha olumlu etkiler gösterdi.* ***Anahtar Kelimeler:*** *Allogreft, rifamisin, çörekotu yağı, histomorfometri, dental implant.*

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Review

COVID-19 PANDEMIC – A REVIEW WITH A DENTAL PERSPECTIVE

ABSTRACT

Novel betacoronavirus is a recent threat to the global health. It has been identified as the cause of the outbreak of respiratory illness that originated in the city of Wuhan, China and has spread rapidly to several other countries within a short span of time. Transmission occurs through respiratory droplets or contaminated surfaces from an infected person, saliva of infected persons has also shown shedding of live virus. Clinical manifestations of COVID-19 can range from mild to severe and can even progress to ARDS and septic shock leading to death. All health care professionals including dental surgeons are at a high risk of acquiring the infection. Dental clinics and hospitals carry a high risk of cross-infection. Aggressive preventive and personal protective measures help in preventing exposure to the infection. Dental professionals should adopt various specific preventive methods and treatment strategies to prevent the spread of the infection in a dental setup.

Keywords: Coronavirus, dental practice management, infection control, pandemic, pneumonia.

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INTRODUCTION

Coronavirus is the recent pandemic that has affected the world and is rapidly spreading. Coronaviruses can infect a wide range of mammals and birds, affecting many organ systems causing a range of infections. They are also known to cause respiratory tract infections in humans, such as Severe acute respiratory syndrome (SARS) and the Middle East respiratory syndrome (MERS).[1] Recently, a novel coronavirus has been identified as the cause of an outbreak of respiratory illness that originated in the city of Wuhan, in China, which has spread to several other countries around the world within a short span of time. This has put the world on high alert for transcontinental transmission of the virus.

History

In1965, Tyrrell and Bynoe[2] discovered the B814 virus, from the human embryonic tracheal organ cultures of adults with common cold. During the same period, Hamre and Procknow[3] isolated a similar type of virus with atypical features. The characteristics of B814 and Hamre's virus were different from any known myxo-or paramyxoviruses and they were collectively called as 229E. Later, Tyrrell along with a group of virologists in the late 1960s found some human and animal strains to be morphologically similar under electron microscopy.[4,5] They were grouped and named as coronaviruses.[6]

In 2002–2003, there was an epidemic of SARS, due to a coronavirus that originated in southern China, initially affecting the Asia–Pacific region, which spread worldwide later. The virus grew easily in tissue cultures. The genomic sequence of which differed from other known coronaviruses.[7] But showed similarity with a virus cultured from Himalayan palm civets. They were collectively called severe acute respiratory syndrome coronavirus (SARS-CoV).[8]

In 2012, a novel beta coronavirus induced respiratory illness leading to morbidity and mortality was reported in Arabian countries.[9] It was found to be spread from dromedary camels to human beings, transmitted by either direct or indirect contact.[10] The virus that caused the infection was initially called as human coronavirus-EMC, but has been later renamed as the Middle East respiratory syndrome coronavirus (MERS-CoV).[11]

On December 8, 2019, many cases of pneumonia due to unknown etiology were reported in the city of Wuhan, Hubei province of China, with manifestations similar to that of a viral etiology. Samples from the lower respiratory tracts of the affected individuals were studied for viral genomic analysis that indicated a novel coronavirus which was subsequently named as 2019 novel coronavirus (2019-nCoV) by the World Health Organisation (WHO).[12] It was reported to cause Severe Acute Respiratory infection (SARI).[13]

Virology

Coronaviruses include a large family of single-stranded enveloped RNA viruses. They belong to the order of Nidovirales, family of Coronaviridae and subfamily of Coronavirinae. They are categorized into four genera as α, β, γ, δ. The remarkable feature of these viruses are the spiky projections on their outer surface giving them the distinctive solar corona or crown appearance, hence called as Coronaviruses. They have unique helically symmetrical nucleocapsids. Specific glycoproteins that are present in the virus include the spike (S), membrane (M), envelope (E), and nucleocapsid (N) proteins.[14] The 2019-nCoV belongs to the β -genus and it comprises of enveloped virions of size 50–200nm in diameter with a single positive RNA genome.[15]

The nucleotide identity of 2019-nCoV exhibits similarity to that of SARS-CoV, hence it was officially named as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).[16] Studies on structural analysis of SARS-CoV-2 have predicted that these viruses use angiotensin-converting enzyme 2 (ACE2) as its host receptor similar to the SARS-CoV. The binding ability of the virus to ACE2 is known to be an important factor determining the infecting and transmitting capability of the virus among humans.[17]

Epidemiology and Transmission

The first case of SARS-CoV-2 induced febrile respiratory illness detected in the city of Wuhan,

in China is continuing to spread to many nations across the world. The virus was thought to be originated from the Huanan Seafood and animal wholesale market after which it was shut from public use on January 1, 2020.[18] Though the origin of SARS-CoV-2 needs further investigation. Few studies have suggested that SARS-CoV-2 was closely related to BatCoV RaTG13 detected in bats of Yunnan Province of China.[19] Transmission can occur both by direct and contact spread to people among close contacts of the affected individuals. The main route of transmission is by respiratory droplets, but surfaces contaminated by an infected person also poses a higher risk.[20]

According to WHO, the total number of confirmed cases reported globally as on April 19th 2020, was about 2,241,359. The maximum number of cases being reported in the United States of America (695,353Cases), The number of cases in Turkey is 82,329. In India, 15,712 cases have been confirmed. SARS-CoV-2 has caused about 152,551deaths globally.[21] Though cases are being recovered, the scientific evidence about the chance of reinfection is still being studied extensively.

Pathogenesis

Though the pathogenesis of SARS-CoV-2 infection is still under extensive research, the mechanism is found to be similar to that of SARS-CoV and MERS-CoV. The S protein of SARS-CoV-2 has a higher binding affinity to the ACE 2 receptors, than SARS-CoV.[15] Once the virus enters the human body the S protein of SARS-CoV aids the virus in entering the host cells. It binds to the ACE2 receptor by establishing fusion of the virus directly to the plasma membrane,[22] clathrin-dependent and independent endocytosis also helps the virus to enter into the host cells.[23] Once the virus enters the host cell translation of the RNA genome occurs and the viral genome starts replication. The viral antigen will be presented to the antigen presenting cells (APC). Antigen presentation will stimulate the humoral and cellular immunity (virus specific B and T cells) of the body. This leads to a severe systemic inflammatory response due to the release of excessive pro-inflammatory cytokines and chemokines by the immune effector cells.[24,25] This cytokine storm will cause an aggressive immunological reaction leading to ARDS, multiple organ failure and even death in severe cases.[26] (Figure 1)

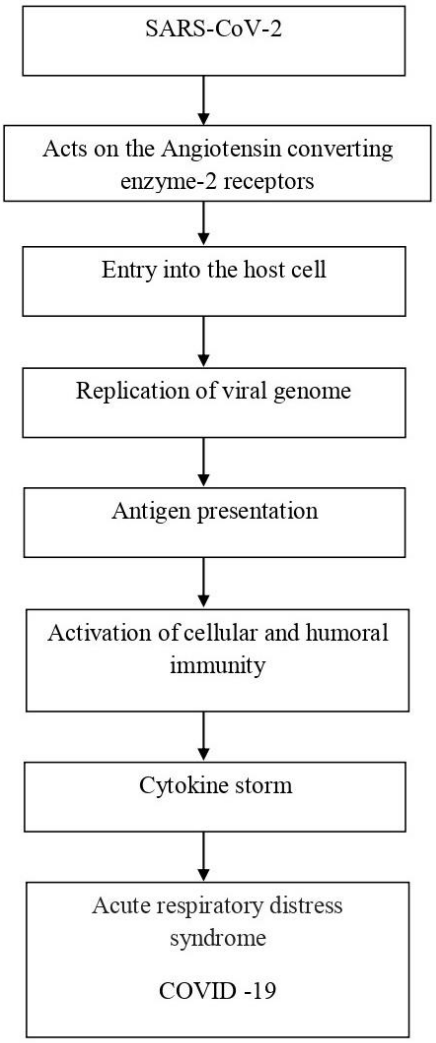

Figure 1: Schematic representation of Pathogenesis of SARS-CoV-2

Clinical manifestations

The signs and symptoms may occur between 2 – 14 days after a SARS-CoV-2 infection[27], but the incubation period ranges from 5-14 days.[21] The clinical manifestations of SARS-CoV-2 infection were reported to be similar to that of previous beta coronavirus infections (i.e SARS-CoV and MERS-CoV) to some extent. Fever, dry cough, dyspnoea were the most common symptoms. Signs like rhinorrhoea, sneezing, or sore throat may denote the location of target cells in the lower airway. The infection may range from mild to severe and can progress to ARDS and septic shock leading to death. Old age, obesity, and the

presence of other comorbid conditions may lead to increased mortality. Computed Tomographic investigation of the chest may reveal ground-glass opacities in the lungs and multiple lobar and sub segmental areas of consolidation.[28] On February 11, 2020, WHO has given an official name for the disease as COVID-19, which means Coronavirus disease- 2019.[29]

Diagnostic methods and Management

Specific RT-PCR tests have enabled the detection of SARS-CoV-2.[30] Specimen required for the diagnosis include upper respiratory tract (URT) specimens like nasopharyngeal and oropharyngeal swabs and lower specimen tract (LRT) specimens like expectorated sputum, endotracheal aspirate, or bronchoalveolar lavage. URT specimen collection should be done using sterile viral swabs made of dacron or rayon and transported in viral media.[13,31] Studies have shown viral cultures of the saliva of confirmed cases to be positive indicating live viral shedding in saliva contributing to transmission of the infection. Hence Saliva can also serve as a promising noninvasive specimen for diagnosis, monitoring, and infection control in patients with SARS-CoV-2 infection.[32]

Management of COVID-19 includes isolation of the patient, early supportive care and constant monitoring. Oxygen supplementation therapy for patients with SARI, hypoxemia or shock, conservative fluid management, appropriate empirical antimicrobials including neuraminidase inhibitors are recommended.[13] Remdesivir, Chloroquine and Hydroxychloroquine has shown in-vitro activity against SARS-CoV-2 (Table 1).[33,34]

Table 1: Recommendations for the use of Remdesivir, Chloroquine and Hydroxychloroquine in the management of COVID-19

Drug	Guidelines
Remdesivir	**Recommended** in hospitalized patients with severe COVID-19 disease, i.e $SpO_2 \leq 94\%$ on ambient air (at sea level), requiring supplemental oxygen, mechanical ventilation, or extracorporeal membrane oxygenation. **Not recommended** for the treatment of mild or moderate COVID-19 outside the setting of a clinical trial. **Not recommended** to use outside a hospital setting / clinical trial.
Chloroquine	**Not recommended** to use high dose of chloroquine for the treatment of COVID-19 disease, because a high dose carries a higher risk of toxicities than a lower dose.
Hydroxychloroquine	**Not recommended** to use outside a hospital setting / clinical trial.

Recent studies have proved the broad spectrum antiviral efficacy of Chloroquine, which is commonly used as an anti-malarial drug.[35] Chloroquine increases the endosomal pH and also interferes with the glycosylation of ACE receptors thereby inhibiting the viral fusion to the host cell. Remdesivir is an adenosine analogue that causes premature termination of the chain leading to inhibition of the viral RNA replication.[33] As of now, there is no approved vaccine for the disease but vaccines for SARS-CoV-2 are under clinical trials.

Dental perspective

As for other health professionals, dental surgeons also have a high risk of acquiring the infection from the patients. In a dental setup, early identification of patients with SARS-CoV-2 is difficult because of nonspecific symptoms and presentation.[36] Hence dental surgeons should follow standard personal protective measures and precautions with all the patients during the period of the pandemic. There are chances that dental surgeons may encounter patients with a travel history from high-risk areas of SARS-CoV-2, hence the dental surgeons should be highly vigilant and have a proper knowledge in suspecting a case of SARS-CoV-2. According to the WHO criteria for suspecting a case,[37]

A. Patient having SARI of no other possible etiology explaining the clinical presentation and a recent travel history or residence in China or other

high-risk countries, in the past 14 days before the onset of symptoms,

B. Patient having any acute respiratory illness and any one of the following in the past 14 days before the onset of symptoms:

1. History of contact with a COVID-19 positive case/probable case of SARS-CoV-2 infection (or) 2. A health care worker working in a setup where COVID-19 positive case/probable cases of SARS-CoV-2 infection were being treated.[37]

If a dental surgeon encounters a suspected/ confirmed case, the patient should be referred to and reported to the public health authority for testing and management of COVID-19.

Preventive measures in dental practice

Health care workers should follow aggressive personal protective methods by using N95 masks, goggles, face shield, protective gowns, etc.[38]Evaluation of the dental patients must be carried out by taking a proper history of the patient, including recent travel history and history of contact with suspected or confirmed cases, Screening patients for signs and symptoms of the infection, Routine temperature assessment of all patients before performing any procedure[39], using mouth rinses of 1% Hydrogen peroxide or 0.2% Povidone in patients before the procedure can reduce the microbial load of saliva including potential SARS-CoV-2 carriage.[40] Use of 0.2% chlorhexidine gluconate as a pre procedural mouthwash has shown significant reduction in the aerosolized microflora generated during ultrasonic scaling.[41]

In a dental setup droplet and aerosol transmission are unavoidable because devices like airotors, ultrasonic scalers work in the patient's oral cavity generating loads of aerosol mixed with saliva and even blood during the procedure. In addition to that cough or saliva of the patient can also contaminate the devices and surfaces.[39] Hence rubber dam isolation, use of high volume saliva ejectors, four-handed technique, anti-retraction handpieces, autoclaving of handpieces after every patient and following strict disinfection protocol may help in reducing the risk of transmission. During the pandemic of COVID-19 use of ultrasonic scalers and procedures that are likely to induce coughing should be avoided.[40] Postponement of elective procedures and providing emergency dental services is recommended.[42] (Table 2)

Table 2: List of emergency, urgent and non-urgent dental needs

Emergency Dental Care	Urgent Dental Care	Non-Urgent / Treatment that can be postponed
• Uncontrolled bleeding • Cellulitis/Space infections • Intra Oral/Extra oral swellings compromising the airway • Trauma involving facial bones	• Severe dental pain/Pulpitis • Pericoronitis • Surgical post-operative osteitis • Dry socket dressing changes • Abscess, or localized bacterial infection resulting in localized pain and swelling • Fracture of Tooth / Orofacial soft tissue trauma • Dental treatment required prior to critical medical procedures. • Final crown/bridge cementation if the temporary restoration is lost, broken or causing gingival irritation • Biopsy of abnormal tissue	• Routine oral examinations and recall visits • Oral prophylaxis • Orthodontic procedures other than those to address acute issues (e.g. pain, infection, trauma) • Extraction of asymptomatic teeth • Restorative dentistry including treatment of asymptomatic carious lesions • Aesthetic dental procedures

Providing emergency dental care

Dental emergencies that need immediate treatment has to be addressed after following the standard precautions. In case of irreversible pulpitis, chemico mechanical carious removal under rubber dam isolation and local anesthesia followed by exposure and devitalization the pulp is recommended to reduce the pain of the patient. Combination of NSAIDs with acetaminophen may also be prescribed for the management of dental pain. Patients who require treatment procedures involving hand pieces should be treated in an

isolated, well-ventilated room.[43] In Patients with intra oral swellings as a result of bacterial abscess, that has a potential risk to develop into a space infection, extractions of the tooth with the pathogenic cause should be preferred rather than a restorative management.[44] If in case extraction of a tooth is needed, absorbable sutures so as to eliminate the need for suture removal are preferred. Management of severe cases of space infections or maxillofacial injuries is recommended to be performed only in a hospital set up so as to screen and test for suspicion of SARS-CoV-2, if required. Emergency treatment in patients who are suspected cases of the infection should be preferably carried out in negative pressure rooms.[43]

Dental imaging during the pandemic

Radiographs are advised only when it is strictly indicated. Intraoral radiographic techniques are not advised because of their ability to induce gag reflex and cough in patients. The intraoral film packet that is placed inside the patient's mouth has a high risk of carriage as it contacts the oral tissues and may possess a serious risk of transmission. Panoramic radiography may be used to evaluate the dental and associated structures instead of intra oral radiographs.[45] Other extra oral radiographic techniques and Cone-beam computed tomography are also recommended in indicated cases.[46]

Telescreening and Patient education

Dental patients should be encouraged to contact the dental clinic/hospital to inform the nature of their dental need prior to their visit. This enables the dental team to telescreen[46] the patient regarding the medical history, travel history, signs and symptoms of the patient and decides whether it is an emergency/urgent/non-urgent dental need. If the dental need of the patient is not an emergency, then the patient can be educated regarding the management and advised for postponement of the dental procedure. In case of an urgent dental need an appropriate appointment schedule can be given, so as to reduce the waiting time of the patient in the dental clinic. This helps the patient by reducing the risk of acquiring any nosocomial infection due to an unwanted visit to a dental setup and also allows the dental surgeon to take care of those patients who need immediate dental care.

CONCLUSIONS

The COVID-19 outbreak has emerged as a reminder of the continuing threat of zoonotic viral diseases to global public health. It is necessary for the dental surgeons and the dental team to be vigilant and protective in providing dental care and also in preventing the SARS-CoV-2 transmission. Though many features of the virus and the disease are still under research, strict surveillance and standard precautions may help in the early identification of the diseased and prevent the further spread of the disease.

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CONFLICT OF INTEREST STATEMENT

None

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Case Report

HEALING OF A LARGE PERIAPICAL LESION AFTER CONVENTIONAL ROOT CANAL TREATMENT: A CASE REPORT

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ABSTRACT

The infected pulp, metabolic products, microorganism toxins, mechanical irritations, chemical agents, trauma, foreign substances, and host defense play a role in periapical tissue diseases. Options for the treatment of large periapical lesions vary from apical surgery and/or non-surgical root canal treatment to extraction. Although apical surgery may be a treatment option in these cases, conventional root canal treatment must be considered as the first alternative. In the present case report, we aimed to report that a surgical approach is not always required in case of a large size of a periapical lesion and healing occurs even in large periapical lesions after conservative endodontic therapy.

Keywords: Root canal therapy, periapical diseases, endodontic inflammations.

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INTRODUCTION

Dental pulp infections are caused by deep caries, mistakes in the dental procedure, trauma, or a combination of these.[1] Most of the periapical lesions of endodontic origin are caused by an inflammatory response in the periradicular tissues of teeth with nonvital pulps. It is caused by an imbalance between host defense and microbial factors. As a result of this, resorption of hard tissues, local inflammation, and destruction of other periapical tissues occur.[2] One of the causes of dental pulp infection, traumatic injuries of teeth generally include the anterior teeth of young patients. The occurrence of pulpal necrosis and microbial infection will cause a periradicular lesion to develop.[1] These periradicular lesions are usually diagnosed when a routine radiographic examination is performed and/or because of acute toothache.[3] It is possible to categorize most of the periradicular lesions (>90%) as dental granulomas, radicular cysts, or dental abscesses.[4] Periradicular lesions cannot be diagnosed as cystic and noncystic lesions according to radiographic characteristics.[2] In addition to radiography, histological examinations are needed for the diagnosis of lesions.[5] Regardless of the size of a lesion, conservative treatments should be the first choice for the treatment of these lesions.[6] In recent years, newer techniques, instruments, and materials have been improved with the increased awareness of the complexity of root canal systems. The above-mentioned advancements have significantly improved the clinician's success rate.[7] Generally, in the conservative treatment of periapical lesions, calcium hydroxide ($Ca(OH)_2$) therapy has been utilized for the stimulation of apexification, the repair of perforations, and the treatment of root fractures and inflammatory root resorptions. $Ca(OH)_2$ has an accelerating effect on periapical tissue healing due to its high pH, neutralization of the acidic products of osteoclasts, induction of cellular differentiation and mineralization.[8] Researchers have reached the general consensus that successful results will be obtained by eliminating bacteria from the root canal system with efficient biomechanical preparation.[9] However, when there is no response to treatment, persistent periradicular lesions may require surgical procedures such as apical resection and curettage.[10]

CASE REPORT

A 20-year-old male patient was referred to the Department of Endodontics at the Dental Faculty of Sivas Cumhuriyet University with the pus drainage in his maxillary right central-lateral incisors and canine tooth. Written informed consent was obtained form the patient who participated in this study. According to a dental anamnesis taken from the patient, the related teeth were traumatized in the past. Periapical radiography (Figure 1) showed the presence of a large lesion in periradicular tissues.

Figure 1. The initial diagnostic periapical radiography of the patient.

The intraoral examination showed that the palatinal cortical bone was perforated. Electronic pulp testing (Electric pulp tester, Parkell, Farmingdale, NY) was applied to the teeth related to the periapical lesion, and the test resulted in a negative response. After evaluating all the diagnostic data, root canal treatment for the teeth of the patient was planned. After local anesthesia, access cavities were prepared and a rubber dam was applied. Necrotic pulp tissues were extirpated, and the working lengths were identified using the electronic apex locator (Propex Pixi; Dentsply Maillefer, Ballaigues, Switzerland). The canals were biomechanically prepared by K-type and H-type hand files using the step-back technique. While performing the instrumentation, the canal was irrigated using 2.5% NaOCl (*Imicryl* Dental,

Konya, Turkey) solution. The final irrigation was performed using 2.5% NaOCl, 17% EDTA (Werax, Turkey), normal saline, and 2% chlorhexidine (Werax, Turkey), respectively. Ca $(OH)_2$ medicament (Kalsin, Turkey) was applied to the root canals, and the access cavity was sealed using Cavit (3M ESPE, Neuss, Germany). There were no symptoms during the second visit, and the root canals were then obturated by employing the cold lateral condensation technique by utilizing AH Plus sealer (Dentsply, Germany) and gutta-percha (Figure 2a).

Figure 2. (a) Postoperative periapical radiograph

Composite resin was used for the restoration of the access cavity. Three months following the filling of the root canals, the patient was still asymptomatic, and a periapical radiograph showed the decreased size of the radiolucency and trabecular bone formation (Figure 2b).

Figure 2. (b) 1 month review,

The patient was examined radiographically for three months (Figure 2c,2d,2e), and during the last control visit (15 months), the radiographic examination demonstrated that healing was continuing (Figure 2f).

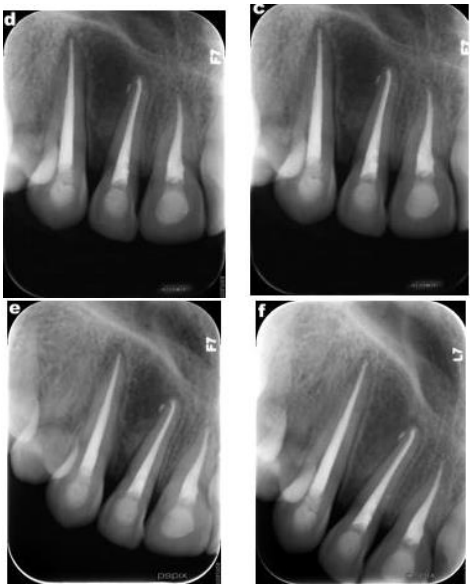

Figure 2.(c) 3 months review, (d) 6 months review, (e) 12 months review (f) 15 months review.

DISCUSSION

After trauma, some pulps remain normal, whereas others become necrotic. Necrotic pulp represents a nutritional supply for pathogenic bacteria, and after a series of reactions, lesions occur in the periradicular region.[11] Although traditional imaging methods are often used for diagnosis and treatment planning in endodontics, advances in imaging technology contribute greatly to the practice of endodontics. Cone-beam computed tomography (CBCT), which were first used in dentistry in 1997 and enable three-dimensional imaging, assist the clinician at every stage of endodontic treatment.[12] In 2011, an attitude statement was published on the use of CBCT in endodontics by the American Endodontics Association (AAE) and the American Academy of Oral and Maxillofacial Radiology (AAOMR). According to the statement CBCT should not be routinely performed in every patient, it should be analysis carefully in cases where traditional diagnostic methods are inadequate.[13] In accordance with the statement, we made our diagnosis and treatment planning with conventional radiographs, because CBCT exposed the patient to extra ionizing radiation. We decided to apply additional diagnostic methods (cbct imaging, aspiration biopsy, etc.) and surgical procedures in case of suspected cystic lesions if we do not respond to our treatment during the follow-up period. There is a disagreement about the treatment method in large

periradicular lesions.[14] Matsumoto *et al*.[15] showed that the prognosis for the treatment of large periradicular lesions was worse in comparison with small lesions. On the other hand, Strindberg[16] and Sjogren *et al*.[17] determined no significant differences in the healing frequency between lesions that were initially larger than 5 mm and lesions that were smaller than 5 mm. Long-term observation is important after the treatment of these lesions. Furthermore, in many studies, apical lesions with a size of up to 20 mm have been reported to improve after conventional root canal treatment.[12] In a long-term clinical study, 42 teeth with large cyst-like lesions were treated by conventional root canal treatment, and 73.8% of all cases were reported to heal completely after non-surgical treatment.[18] There are also disadvantages such as reducing bone support, destroying the inner blood vessels and nerves that feed the teeth adjacent to the surgical site, damaging the mental foramen, lower alveolar nerve branch and/or anatomical structures such as artery, nasal cavity, maxillary sinus, the formation of anatomical defects, postoperative pain, and the inability to apply surgery to pediatric patients in the surgical treatment of cystic lesions in terms of cooperation.[19] We preferred the traditional root canal treatment considering these case studies and disadvantages of surgical treatment. Also with the development of technology, regenerative treatment methods have been developed as an alternative to classical treatment methods. The aim of these methods is to replace damaged cells in the root canal system with a new one and reconstruct pulp vitality.[20] There are some disadvantages clinical and biological complications such as color change in the crown, development of resistant bacterial strains and allergic reactions can be observed. In addition, if necrosis has developed completely in the pulp tissue, revascularization may not be possible.[21] Whether the root canal obliteration and / or apical periodontitis will develop in the long term has not been exactly established.[22] Most of the studies in the literature are limited with animal experiments, in vitro studies and case reports of studies on humans.[20] Therefore, more clinical trials with long-term follow-up are needed to eliminate existing disadvantages.[23] Considering these disadvantages, we did not prefer regenerative endodontic treatment in our case. We wanted to emphasize once again that the routine treatments used in endodontics may also improve in large infections and show that it can be successful when traditional treatment is performed in the appropriate protocol without requiring an additional procedure. Conventional root canal treatment is based mainly on removing a microbial infection from the root canal system. Irrigation agents used during the biomechanical preparation help reduce the microbial flora of the infected root canals.[24] Furthermore, Ca(OH)2 treatment for a certain period before the endodontic treatment of large periapical lesions is complete has a positive effect on the disappearance of symptoms and the control of periradicular infection.[25] Ca(OH)2 makes a contribution to the healing of periradicular lesions through an anti-inflammatory effect, neutralization of acid products, alkaline phosphatase activation and antibacterial effect.[26] We preferred Ca(OH)2 treatment before the endodontic treatment of large periapical lesions was complete in our study and completed our treatment when the related teeth became asymptomatic. In the radiographic examination, density change within the lesion, trabecular reformation, and lamina dura formation, and in the clinical examination, asymptomatic teeth and healthy soft tissue7 show us that the treatment has been successful during periodic check-up visits.

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None

CONFLICTS OF INTEREST STATEMENT

The authors declare no conflicts of interest.

Geniş Periapikal Lezyonların Geleneksel Kök Kanal Tedavisini Takiben İyileşmesi: Vaka Raporu

ÖZ

Periapikal dokularda lezyon gelişmesinde enfekte pulpa, mikroorganizmaların toksinleri, metabolik ürünler, kimyasal ajanlar, mekanik irritasyonlar, yabancı maddeler, travma ve konak savunması rol oynamaktadır. Büyük periapikal lezyonların tedavisi için seçenekler, cerrahi olmayan kök kanal tedavisi ve/veya apikal cerrahiden çekime kadar değişmektedir. Bu olgularda apikal cerrahi bir tedavi seçeneği olabilse de konvansiyonel kök kanal tedavisi ilk tercih olmalıdır.

Bu olgu sunumunun amacı, geniş apikal lezyonların her zaman cerrahi tedaviye ihtiyaç olmaksızın konservatif bir endodontik tedaviyi takiben iyileştiğini göstermektir.

Anahtar Kelimeler: *kök kanal tedavisi, periapikal hastalıklar, endodontik inflamasyon.*

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