Cumhuriyet Dental Journal

27 (2): 2024

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

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

Cumhuriyet Dental Journal

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

Aims and Scope

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ISSN 1302-5805

e-ISSN 2146-2852

Volume/27- Issue/2-2024

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DOI: https://doi.org/10.7126/cumudj.1373300

Cumhuriyet Dental Journal

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

Awareness of Potential Oral and Systemic Risk Factors for Covid-19 Among Dentists

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Research Article

History

Received: 09/10/2023
Accepted: 21/05/2024

ABSTRACT

Aim: Although the pathophysiological pathways have not been fully elucidated, it is assumpted that the systemic comorbidity variables described for periodontal disease may also apply to COVID-19. It was aimed to assess dentists' knowledge in the triangle of systemic comorbidities, oral-periodontal health, and COVID-19 and to contribute to patient care.

Methods: A questionnaire containing 17 statements obtained from hypotheses in the current literature was sent to dentists via email. The first part of the survey contains demographic questions, including age, gender, speciality, years in professional experience, and institutional affiliation, while the second part contains statements assessing dentists' knowledge about oral and systemic candidate risk factors related to COVID-19. Responses were set up as "agree", "disagree", and "undecided". Intraclass Correlation Coefficient (ICC) was calculated for each item. An ICC value of 0.80 or higher was considered satisfactory.

Results: 68.8% (n=353) of 513 dentists were female, 66.7% (n=342) were between the ages of 24-40, 67.3% (n=345) had a professional history of 10 years or more, and 49.9% (n=256) were specialists. 56.5% of participants agree that there may be common risk factors for periodontal disease and COVID-19. 74.1% of participants agree that improving oral care levels could reduce complications arising from COVID-19. The systemic diseases/conditions for severe COVID-19 that received the highest "agree" responses in the presence of periodontal disease were Diabetes (90.1%), Tuberculosis (87.7%), and AIDS (86.7%). The highest "undecided" responses were for independent statements created for relationships with necrotizing oral manifestations with fever upon COVID-19 diagnosis (42.3%), vesiculobullous lesions/ulcers (41.7%), atherosclerotic diseases (42.1%), and liver diseases (40.2%). The highest "disagree" response was for the presence of vesiculobullous lesions/ulcers with a COVID-19 diagnosis (17%). Compared to male, female participants used the "agree" statement more for independent statements given for AIDS, presence of common risk factors, pregnancy, and atherosclerosis ($p<0.01$) and for oral care level, COPD, liver diseases, and rheumatoid arthritis ($p<0.05$). The specialists of Periodontology gave more "agree" responses for statements about the course of COVID-19 with oral care level, periodontal disease and dysbiotic flora, the course of COVID-19 with periodontal disease and pregnancy, and the course of atherosclerosis-COVID-19.

Conclusions: Within the limitations of the time of our study and the participating dentist population, it was observed that a sufficient correlation could not be established between COVID-19 and oral/periodontal health and the presence of systemic comorbidities, and there's a need to raise awareness through necessary training/seminar programs.

Keywords: Covid-19, Periodontal Disease, Dentists, Questionnaire.

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How to Cite: Karakıs Akcan S, Mamaklıoğlu D, Meşeli SE. (2024) Awareness of Potential Oral and Systemic Risk Factors for Covid-19 Among Dentists, Cumhuriyet Dental Journal, 27(2):69-78.

Introduction

COVID-19 is an acute respiratory infection caused by coronavirus 2 (SARS-CoV-2) and transmitted through airborne droplets and aerosols.[1] The binding of the spike protein on the surface of SARS-CoV-2 to the angiotensin-converting enzyme 2 (ACE-2) receptor found on the human cell membrane facilitates transmission.[2] This enzymatic expression occur both in the lungs and in many other organs such as kidneys, testes, female breasts, liver, and cardiovascular and gastrointestinal systems. Therefore, it is presumed that SARS-CoV-2 could affect multiple organs in the body.[3,4] The receptors to which the proteins used by SARS-CoV-2 bind to infect cells are also abundantly present in the oral cavity.[5,6]

The ulcerated pocket epithelium in periodontitis may facilitate COVID-19 entry, either directly through this damaged epithelium or indirectly by the upregulation of ACE-2 receptor expression induced by periodontal pathogens.[1,7] SARS-CoV-2 RNA has been detected in dental calculus, supragingival, and subgingival plaque biofilms of severe COVID-19 patients.[8,9] The presence of SARS-CoV-2 in cadaver biopsies of periodontal tissue indicates a relationship between COVID-19 and periodontitis.[10] Periodontitis could also serve as a source of systemic infection, possibly exacerbating severe COVID-19

through a cytokine storm.[1,7,11] In COVID-19 patients with periodontitis, oral and respiratory bacteria can potentially spread to the lower respiratory tract through aspiration.[12] Therefore, many researchers emphasized that the oral cavity acts as a reservoir for SARS-CoV-2.[1,5]

In some study results revealed increased intensive care admissions and mortality rates in severe periodontitis patients suffered from COVID-19.[13,14] Furthermore, researches have shown that the presence of alveolar bone loss and caries associated with apical periodontitis in individuals with a systemic disease can lead to worsening of COVID-19 complications.[13,15] Individuals suffered from periodontitis are 4.7 times more likely to develop coronavirus disease.[16] Acute periodontal lesions, particularly necrotizing forms, are predicted to emerge in association with COVID-19.[6,17,18] Also, non-specific oral lesions, such as dry mouth, oral vesiculobullous or pustular lesions, lip necrosis, fissured tongue, or erythematous or hemorrhagic mucosal lesions, have also been associated with COVID-19.[6,18] Gender (male), smoking/alcohol consumption, hypertension, obesity, diabetes, cardiovascular diseases, chronic obstructive pulmonar disease, chronic kidney and liver diseases, cancer, immunological disorders, Acquired Immune Deficiency Syndrome (AIDS), and atherosclerotic disorders have been cited as common risk factors for both periodontitis and COVID-19.[1,7,13]

Based on the assumption that the existence of a bidirectional relationship between periodontal diseases and systemic diseases may affect the course of COVID-19, this study aimed to evaluate the knowledge and awareness of dentists regarding the possible effect of periodontal diseases and systemic diseases comorbidity on the course of COVID-19.

Methods

Study design and population

This cross-sectional survey-based study protocol was approved by The Istanbul Aydin University Ethics Committee for Non-interventional Researches (Ethics Committee No. 2021/352). The study conducted between February 2021 and March 2021 in accordance with the Declaration of Helsinki of 1975, seventh revised version in 2013. The research population consisted of 513 dentists who were met all inclusion criteria listed below.

Inclusion criteria for the study were as follows;

- Graduated from a faculty of dentistry.
- Being between the ages of 23-60
- Speaking Turkish as native language
- Being a member of the Turkish Dental Association
- Being volunteer to participate

Data collection tool

A 2-sectioned questionnaire which was structured regarding utilized the information at the hypothesis level in the current literature, was sent to the dentists via e-mail. Section A included demographic questions including age, gender, expertise, work experience in the profession, institutional affiliation. To evaluate dentists' knowledge of oral and systemic candidate risk factors for COVID-19, Section B was structured with 17 statements. These statements classified in 3 distinct subsections and could be responded with one of the possible options were as "Agreed, Undecided or Disagreed". Subsection G consisted of only one statement (G1) that evaluated general information about the virus family from which COVID-19 originates. While Subsection P included 6 statements (P1-6) which asked for assessing the relationship between COVID-19 and periodontal disease and the presence of oral findings, Subsection S consisted of 10 statements (S1-10) that placed for effect of systemic comorbidities on the course of COVID-19 with periodontal disease.

An expert panel consisting of a public health specialist, an internal medicine specialist, two periodontists and a non-specialist dentist was assigned for content validation of the questionnaire in line with the Lawshe method.[19] Following the panel's recommendations, a revised version of the data collection tool was developed. This amended version of was e-mailed to ten dentists who were randomly selected from Dental Health Research and Training Centers both of Beykent University and of Istanbul Aydin University. These dentists did not participate for the study. The Intraclass Correlation Coefficient (ICC) was calculated for test-retest reliability and inter-responder reliability for each item. An ICC value of 0.80 or higher was deemed satisfactory.[20] Subsequently, an URL supplied for direct access to the data collection tool prepared digitally in Google forms and URL was shared to all registered members of the Turkish Dental Association via membership e-mailing system. To avoid duplicate inclusion, e-mailing list of participants were provided to only one author (SEM) in accordance with relevant data protection regulations.

Statistical analysis

Sample size

Before the study, a power analysis was conducted to determine the appropriate sample size for the study. Similar studies in the literature conducted with sample sizes ranging from 245-568 subjects.[21,22] The total number of participants was 376, as determined by the G-POWER algorithm, with an effect size of 0.17, 95% power, and a margin of error of 0.5. Since the study was conducted with a single group, the required sample size for this study was established as n=376. The study had a participation of 513 dentists.

Data Analysis

The SPSS (Statistical Package for Social Sciences) 24.0 software was utilized for the statistical analysis of the research data. Descriptive statistical data were represented as frequency, mean, and percentage. The Student t-test was applied for the comparison of quantitative data with normal distribution between two groups, while the One-Way Anova test was chosen for comparisons among more than two groups. The Pearson Chi-Square test was applied to evaluate responses based on demographic categories. Significance was set at $p<0.05$ and $p<0.01$ level.

Results

The demographic characteristics of the study is presented in Table 1. Based on Table 1, 68.8% (n=353) of the participants in the study were female and mean age of population was 38.84. Considering distribution of age groups, 22.6% (n=116)

were 30 years-old or younger, 44.1% (n=226) were between the ages of 31-40. Moreover, 67.3% (n=345) of the participants, had a professional work experience period 10 years or over. While 50.1% (n=257) of the participants did not have a specialty, 49.9% (n=256) did have. The type of institutions participants worked were as follows: 26.1% (n=134) of at a university hospital, 17.7% (n=91) of at a hospital belonged to Ministry of Health, and 56.2% (n=288) in a private clinic.

The distribution of responses was presented in Table 2. The statement "There may be common risk factors for periodontal disease and COVID-19" received 56.5% agreement, 8.8% disagreement, and 34.7% were uncertain. The following statements received 80% or higher agreement: "The presence of periodontal disease in individuals with diabetes can adversely affect the progression of COVID-19." (90.1%), "COVID-19 is caused by a newly identified coronavirus called SARS-CoV-2." (88.7%), "The presence of periodontal disease in individuals with tuberculosis can adversely affect the progression of COVID-19." (87.7%), and "The presence of periodontal disease in AIDS patients can adversely affect the progression of COVID-19." (86.7%).

The statement with the highest disagreement was: "Patients with painful vesiculobullous lesions and oral ulcers upon intraoral examination can be evaluated for COVID-19." (17%). The highest undecided responses were given for the statements: "The presence of necrotizing periodontal disease accompanied by high fever and similar presentations may suggest COVID-19." (42.3%), "The presence of periodontal disease in individuals with atherosclerosis can adversely affect the progression of COVID-19." (42.1%), "Patients with painful vesiculobullous lesions and oral ulcers upon intraoral examination can be evaluated for COVID-19." (41.7%), and "The presence of periodontal disease in individuals with liver disease can adversely affect the progression of COVID-19." (40.2%).

Gender

Responses each of "P1" (p=0.014; p<0.05), "P6" (p=0.002; p<0.01), "S3" (p=0.007; p<0.01), "S4" (p=0.015; p<0.05), "S5" (p=0.037; p<0.05), "S6" (p=0. 04; p<0.01), "S7" (p=0.022; p<0.05), "S8" (p=0.023; p<0.05), "S9" (p=0.07; p<0.01) were statistically different regarding gender. The agreement rate on each of above said nine statements was higher in women (Table 3.). No difference was found between the gender groups for the remained 11 statements (p>0.05).

Age

Responses to the “P5” differed significantly according to age (p=0.007; p<0.01). In the paired comparisons, the rate of agreement at the age of 30 and younger group was found to be lower than both of other two groups (p=0.001). In addition, significantly higher the rate of agreement for the "S4" than the age subgroup of 51-60 (p=0.045; p<0.05). The “S6" for the same age subgroup was shown a higher rate of agreement than both remained two age subgroups (p=0.001) (Table 4). The agreement rates of remained statements was not reveal any difference regarding age subgroups (p>0.05).

Years of professional experience

As shown in Table 4, the rate of agreement for “G1” was found to be lower in those with 0-4 years of professional experience compared to those with 5-9 years of professional experience. (p=0.043; p<0.05). In the pairwise comparisons for the statement "P1", the rate of agreement among those with 5-9 years of professional experience was higher than 0-4 years (p=0.047) and 10 years and over (p=0.048). For the statement "P5", the rate of agreement was higher in those with 10 years and over than in those with 0-4 years (p=0.032) and 5-9 years (p=0.033). Furthermore, for the statement "S4", the rate of agreement was found to be lower in those with 0-4 years of professional experience compared to those with 10 years or more (p=0.001; p<0.01). No statistically significant difference was found between the subgroups in terms of other statements (p>0.05) (Table 4).

Speciality

In the pairwise comparisons for the statement "G1" according to specialty, the rate of agreement of non-specialists was lower than both of periodontists (p=0.001) and of other specialists (p=0.001). The rates of agreement for the statements "P1" and “S3” was lower in non-specialists than in periodontists (respectively, p=0.041; p<0.05, p=0.029; p<0.05). Moreover, while for the statement "P3", the rate was higher in periodontology specialists than in other specialties (p=0.027; p<0.05), the rate of “S9” was higher in periodontists than both in remained specialists and non-specialists (for both, p=0.001; p<0.05). No difference was found between the groups for the remained statements (p>0.05) (Table 5).

Institutional affiliation

The answers given to the question "P1" differed significantly according to the institutional affiliation." In the pairwise comparisons for the statement "P4", the rate of agreement was higher among those working at the university hospital than both those working at the centers belonged to Ministry of Health (p=0.001; p<0.01) and those working in private practice or clinics (p=0.043; p<0.01). Furthermore, for the statement "S3", the rate of agreement was higher among those working at university hospitals than those working at private practices or clinics (p=0.031; p<0.01). But, for the statement "S8", the rate of agreement was higher among those working at the centers belonged to Ministry of Health than those working in private clinic (p=0.010; p<0.05). For the statement "S9", the rate was higher among those working in university hospitals than those working in private clinics (p=0.019; p<0.05). No statistically significant difference was found between the groups for the other statements (p>0.05) (Table 4).

Table 1: Demographic distribution

	N	%
Gender		
Male	160	31.2
Female	353	68.8
Age		
≤ 30 years	116	22.6
31-40 years	226	44.1
41-50 years	92	17.9
51-60 years	49	9.6
≥ 61 years	30	5.8
Professional experience (years)		
0-4	80	15.5
5-9	88	17.2
≥10	345	67.3
Branch of Speciality		
General dentistry	257	50.1
Maxillofacial surgery	31	12.1
Maxillofacial radiology	10	3.9
Endodontics	29	11.3
Orthodontics	21	8.2
Pedodontics	16	6.3
Periodontics	83	32.4
Prosthodontics	45	17.6
Restorative dentistry	21	8.2
Institutional affiliation		
University	134	26.1
Ministry of health	91	17.7
Private clinic	288	56.2

Table 2: Distribution of responses to the questionnaire statements

			Agree		Disagree		Undecided	
			N	%	N	%	N	%
PERIODONTAL RISK	G1	The agent for COVID-19 is a newly identified coronavirus called SARS-CoV-2.	455	88.7	41	8.0	17	3.3
	P1	Improving the level of oral care and reducing the oral bacterial load can reduce the complications of COVID-19	380	74.1	53	10.3	80	15.6
	P2	Periodontal pockets may be reservoirs for SARS-CoV-2.	291	56.7	39	7.6	183	35.7
	P3	Patients with periodontal disease with more severe COVID-19 disease may develop oral dysbiosis and more pathogenic flora structure.	301	58.7	8	1.6	204	39.8
	P4	In necrotic periodontal disease, accompanied by high fever, and similar tables, the presence of COVID-19 can be considered.	239	46.6	57	11.1	217	42.3
	P5	Patients with painful vesiculosal lesions and oral ulcers can be evaluated for COVID-19.	212	41.3	87	17.0	214	41.7
	P6	There may be common risk factors for periodontal disease and COVID-19.	290	56.5	45	8.8	178	34.7
SYSTEMIC RISK	S1	In individuals with diabetes, the presence of periodontal disease may adversely affect the course of COVID-19.	462	90.1	12	2.3	39	7.6
	S2	In individuals with obesity, the presence of periodontal disease may adversely affect the course of COVID-19.	398	77.6	21	4.1	94	18.3
	S3	In pregnancy, the presence of periodontal disease, gestational diabetes, pre-eclampsia and other factors can also adversely affect the course of COVID-19.	333	64.9	23	4.5	157	30.6
	S4	In individuals with chronic obstructive lung disease, the presence of periodontal disease may adversely affect the course of COVID-19.	340	66.3	22	4.3	151	29.4
	S5	The presence of periodontal disease in smokers may adversely affect the course of COVID-19.	393	76.6	40	7.8	80	15.6
	S6	The presence of periodontal disease in AIDS patients may adversely affect the course of COVID-19.	445	86.7	7	1.4	61	11.9
	S7	In individuals with liver disease, the presence of periodontal disease may adversely affect the course of COVID-19.	276	53.8	31	6.0	206	40.2
	S8	In individuals with rheumatoid arthritis, the presence of periodontal disease may adversely affect the course of COVID-19.	275	53.6	35	6.8	203	39.6
	S9	In patients with atherosclerosis, the presence of periodontal disease may adversely affect the course of COVID-19.	261	50.9	36	7.0	216	42.1
	S10	In individuals with tuberculosis, the presence of periodontal disease may adversely affect the course of COVID-19.	450	87.7	9	1.8	54	10.5

G: General statement; P: Periodontal risk statements; S: Systemic risk statements

Table 3: Evaluation of the answers given to the statements by gender

		Gender				[a]p
		Male (n=160)		Female (n=353)		
		N	%	N	%	
P1	Agreed	107	66.9	273	77.3	***0.014****
	Disagreed	25	15.6	28	7.9	
	Undecided	28	17.5	52	14.7	
P6	Agreed	76	47.5	214	60.6	***0.002****
	Disagreed	23	14.4	22	6.2	
	Undecided	61	38.1	117	33.1	
S3	Agreed	90	56.3	243	68.8	***0.007****
	Disagreed	12	7.5	11	3.1	
	Undecided	58	36.3	99	28.0	
S4	Agreed	101	63.1	239	67.7	***0.015****
	Disagreed	13	8.1	9	2.5	
	Undecided	46	28.7	105	29.7	
S5	Agreed	113	70.6	280	79.3	***0.037****
	Disagreed	19	11.9	21	5.9	
	Undecided	28	17.5	52	14.7	
S6	Agreed	127	79.4	318	90.1	***0.004****
	Disagreed	3	1.9	4	1.1	
	Undecided	30	18.8	31	8.8	
S7	Agreed	72	45.0	204	57.8	***0.022****
	Disagreed	13	8.1	18	5.1	
	Undecided	75	46.9	131	37.1	
S8	Agreed	72	45.0	203	57.5	***0.023****
	Disagreed	15	9.4	20	5.7	
	Undecided	73	45.6	130	36.8	
S9	Agreed	65	40.6	196	55.5	***0.007****
	Disagreed	13	8.1	23	6.5	
	Undecided	82	51.2	134	38.0	

[a]Pearson Chi-Square ***p<0.01* **p<0.05*

Table 4: Evaluation of the answers according to age, institutional affiliation, and professional experience

		Age (years)										
		≤30 (n=116)		31-40 (n=226)		41-50 (n=92)		51-60 (n=49)		≥60 (n=30)		
		N	%	N	%	N	%	N	%	N	%	[a]p
	Agreed	34	29.3	91	40.3	45	48.9	25	51.0	17	56.7	
P5	Disagreed	23	19.8	35	15.5	11	12.0	12	24.5	6	20.0	***0.007****
	Undecided	59	50.9	100	44.2	36	39.1	12	24.5	7	23.3	
	Agreed	93	80.2	140	61.9	59	64.1	29	59.2	19	63.3	
S4	Disagreed	6	5.2	10	4.4	3	3.3	2	4.1	1	3.3	***0.038****
	Undecided	17	14.7	76	33.6	30	32.6	18	36.7	10	33.3	
	Agreed	107	92.2	198	87.6	84	91.3	34	69.4	22	73.3	
S6	Disagreed	0	0	6	2.7	1	1.1	0	0	0	0	***0.001****
	Undecided	9	7.8	22	9.7	7	7.6	15	30.6	8	26.7	
		Professional Experience (years)										
		0-4 (n=80)				5-9 (n=88)				≥10 (n=345)		
		N		%		N		%		N	%	[a]p
	Agreed	64		80.0		81		92.0		310	89.9	
G1	Disagreed	9		11.3		6		6.8		26	7.5	**0.026***
	Undecided	7		8.8		1		1.1		9	2.6	
	Agreed	57		71.3		73		83.0		250	72.5	
P1	Disagreed	4		5.0		7		8.0		42	12.2	**0.029***
	Undecided	19		23.8		8		9.1		53	15.4	
	Agreed	23		28.7		27		30.7		162	47.0	
P5	Disagreed	18		22.5		16		18.2		53	15.4	**0.006****
	Undecided	39		48.8		45		51.1		130	37.7	
	Agreed	64		80.0		63		71.6		213	61.7	
S4	Disagreed	2		2.5		8		9.1		12	3.5	**0.001****
	Undecided	14		17.5		17		19.3		120	34.8	
		Institutional affiliation										
		Academic (n=134)				Public (n=91)				Private clinic (n=288)		
		N		%		N		%		N	%	[a]p
	Agreed	126		94.0		77		84.6		252	87.5	
G1	Disagreed	4		3.0		6		6.6		31	10.8	**0.001***
	Undecided	4		3.0		8		8.8		5	1.7	
	Agreed	73		54.5		44		48.4		122	42.4	
P4	Disagreed	14		10.4		3		3.3		40	13.9	**0.013***
	Undecided	47		35.1		44		48.4		126	43.8	
	Agreed	100		74.6		65		71.4		168	58.3	
S3	Disagreed	5		3.7		2		2.2		16	5.6	**0.010***
	Undecided	29		21.6		24		26.4		104	36.1	
	Agreed	83		61.9		58		63.7		134	46.5	
S8	Disagreed	7		5.2		3		3.3		25	8.7	**0.006****
	Undecided	44		32.8		30		33.0		129	44.8	
	Agreed	86		64.2		39		42.9		136	47.2	
S9	Disagreed	4		3.0		8		8.8		24	8.3	**0.005****
	Undecided	44		32.8		44		48.4		128	44.4	

[a]Pearson Chi-Square ***p<0.01* **p<0.05*

Table 5: Evaluation of the answers according to branch of speciality

		Speciality						
		General dentistry		Periodontics		Other specialties		
		N	%	N	%	N	%	[a]p
G1	Agreed	212	82.5	80	97.6	163	93.7	***0.001****
	Disagreed	31	12.1	1	1.2	9	5.2	
	Undecided	14	5.4	1	1.2	2	1.1	
P1	Agreed	180	70.0	69	84.1	131	75.3	***0.018****
	Disagreed	36	14.0	1	1.2	16	9.2	
	Undecided	41	16.0	12	14.6	27	15.5	
P3	Agreed	156	60.7	57	69.5	88	50.6	***0.006****
	Disagreed	7	2.7	0	0	1	0.6	
	Undecided	94	36.6	25	30.5	85	48.9	
S3	Agreed	150	58.4	65	79.3	118	67.8	***0.010****
	Disagreed	15	5.8	2	2.4	6	3.4	
	Undecided	92	35.8	15	18.3	50	28.7	
S9	Agreed	110	42.8	58	70.7	93	53.4	***0.001****
	Disagreed	23	8.9	2	2.4	11	6.3	
	Undecided	124	48.2	22	26.8	70	40.2	

[a]*Pearson Chi-Square* **p<0.01* **p<0.05*

Discussion

Within the period and population of this cross-sectional study, it was found that Turkish dentists were unable to establish an adequate relationship between the oral manifestations that may be associated with COVID-19, the possible effects of periodontal diseases, and the impact of periodontal diseases on the course of COVID-19 in the presence of systemic comorbidities.

The COVID-19 classification was answered correctly by 88.7% of the dentists. The highest "agreed" responses were given by dentists with 5-9 years of work experience, dentists working at universities and periodontists, while the lowest "agreed" responses were given by dentists with 0-4 years of professional experience, dentists working for Ministry of Health and non-specialized dentists. In the study by Karayürek *et al.,* 79.3% of the participants answered the question correctly.[23] The reason for the higher response rate in our study may be the increase in the general knowledge level of dentists one year after the outbreak of the pandemic.

For the statement "There may be common risk factors for periodontal disease and COVID-19", 56.5% of dentists answered "agreed", 8.8% answered "disagreed" and 34.7% were undecided. The first officially known COVID-19 case in Turkey was detected on March 10th 2020. This study was conducted between February and March 2021, when the first shock moments related to COVID-19 were overcome and clinical results started to be reported. Sensitive populations, age groups, risk factors that will be more affected from COVID-19 disease were mostly presented as hypotheses in the literature, and large clinical results could not be fully reported because they were not yet available. While some of the statements we created had current content related to COVID-19 (diabetes, smoking, pregnancy, tuberculosis(TBC)) others were hypotheses that were less found in the literature.[13,24,25]

Duruk *et al*. reported that 96.27% of Turkish dentists obtained information about COVID-19 through their personal websites/social media accounts, whilst only 26.65% of them attended an informative meeting about COVID-19. [26] They also reported that 91.37% of them were informed through the Ministry of Health, WHO and professional organizations and/or their social media accounts.[26] Considering these sources, the statements in the questionnaire (diabetes, TBC and AIDS) with high agreement (80% and above) were predictable. An important limitation of this study was that the information sources of the dentists regarding COVID-19 were not assessed.

There are different studies in the literature evaluating dentists' knowledge of the relationship between periodontal/oral health and systemic diseases/conditions. In a recent survey conducted in 2008 with nearly 2000 USA dentists found that hypertension (85.8%), cardiovascular disease (76.8%), diabetes (76.6%), hepatitis (71.5%), and HIV infection (68.8%) had significant clinical implications for the majority of dentists.[27] Another study reported high dentist awareness of the relationship between periodontal disease, diabetes (84.4%) and heart disease (70.2%).[28] Dentists' awareness was lower for the association of periodontal disease with respiratory tract disease (24.4%), kidney disease (31.6%) and stroke (37%).[28] Paquette *et al.* reported that dentists evaluated the evidence as strong for the association between cardiovascular disease (71.1%) diabetes mellitus (67.0%) and pregnancy complications (38.1%), but found the evidence insufficient for respiratory diseases, osteoporosis and obesity.[29] Nazir *et al.* stated that women's awareness of the relationship between periodontal health and systemic diseases was higher compared to men, and this awareness stood out for negative pregnancy outcomes, diabetes, and rheumatoid arthritis.[28] Based on outcomes of the presented

study, women participants opted the response of “agree” more for the common systemic comorbidities presented for COVID-19. Moreover, women consented on the statements asked the relationships between both periodontal disease and COVID-19, and each of the conditions/diseases listed as pregnancy, COPD, smoking, HIV, liver diseases, RA, atherosclerosis. But, the effect of higher ratio of women participants should be taken into account in the interpretation of the outcomes. Although the rate of male physicians is higher according to the Turkish Dentists Association data(2022), the participation rate in the study may also indicate that women allocate more time for academic development[28] and have more curiosity and interest in the subject. Considering all these findings, greater pre-awareness, especially in women, may have formed the basis for associating COVID-19 and comorbidities. Another limitation of this study is that a preliminary questionnaire prepared with statements independent from COVID-19 did not conduct. In this study, similar to the relevant literature given above, the highest "agree" responses were noticed especially for diabetes (90.1) and AIDS. "Agreed" option was less favored for smoking (76.6), obesity (77.6), pregnancy (64.9), liver disease (53.8), RA (53.6) and atherosclerosis (50.9.)

Physician awareness questionnaires, which measure the general knowledge level, anxiety levels, and attitudes about the vaccine, covering the transmission routes and countermeasures related to COVID-19, have been reported. Karayürek *et al.* reported that specialized dentists had higher levels of knowledge, and age and work experience did not have an effect on the level of knowledge.[23] Similarly, Gambhir *et al.* found that education level and health sector profile were associated with average knowledge levels in India.[21] They reported that dentists who continued their academic life have higher scores because they had the opportunity to access and achieve more regular information without any relationship with work experience in profession.[21] In this study, dentists with periodontology expertise, compared to dentists without expertise, gave more "agreed" answers for "COVID-19 course with oral care level", "periodontal disease and COVID-19-pathogenic flora", "periodontal disease and pregnancy and COVID-19 course", "atherosclerosis and COVID-19”. Presented study seems to support these two studies in terms of increasing the level of knowledge of academic continuity. Unlike these studies, the institution, work experience and age, together with the specialty, appears to be effective on the level of knowledge of dentists.

Another situation that may indirectly effect the level of knowledge may be the relationship between the institution and the level of fear and anxiety. It has been reported that dentists working under the Ministry of Health experience relatively more anxiety due to their employment to be taken as a risk factor at home, while dentists working at universities had the highest perceived anxiety and fear due to the risk that the COVID-19 pandemic would adversely effect their academic attendance.[23] Although the fear and anxiety levels of dentists working in private clinics were reported to be low, economic concerns in particular were challenging for these dentists. [23] Karaaslan *et al*. found that more than half (52.6%) of dentists working in their private clinics stated that they only cared for emergency patients during the pandemic period.[30] Most of the dentists (97.4%) stated that the pandemic had a negative impact on their economic situation.[30]According to outcomes of the study conducted by Tunçer and Karkaç in February 2021, 59% of dentists working in their own clinics and 50% of those working in public or private institutions reported that they reduced the number of patients during the pandemic period.[31] While the rate of only emergency caregivers was 8.8% among those working in their own clinic, it was determined as 32.4% of those working in an institution.[31] Other economic issues for dentists could be listed as difficulty in accessing protective equipment, having COVID, having a chronic illness, and having to interrupt their work for these reasons.[26,31] The decrease in the rates of emergency patient care among dentists working in their own clinics has been interpreted as the fact that dentists had to work for economic reasons in the later stages of the pandemic. 56.2% of the participants in this study worked in private practice/clinics, 26.1% in university hospitals, and 17.7% in the ministry of health. Other factors that may influence on the responses to the questionnaire statements; dentists themselves or their relatives having COVID-19, having a chronic disease could be listed as only emergency patient/normal patient care processes (awareness of oral manifestations).

We got the highest agreement rate for the relationship between oral care level and COVID-19 for statements in the oral manifestations-COVID-19-periodontal disease triangle, The statements with the lowest agreement rate were given for the presence of vesiculobullous lesion/ulcer in the mouth and necrotizing periodontal disease in the diagnosis of COVID-19, independently. Iranmanesh *et al*. reported that more common and severe oral lesions sere seen in older ages and patients with severe COVID-19.[6] While taste disturbance was the most common and first described oral symptom, the oral manifestations associated with COVID-19 were ulcers, erosions, bullae, vesicles, pustules, and fissures, or depapilla tongue, macule, papule, plaque, pigmentation, halitosis, white areas, necrosis, petechiae, edema, erythema, spontaneous bleeding. The most affected sites were reported as tongue, labial mucosa, and palatal region, respectively. The suggested diagnoses for the lesions were listed as aphthous stomatitis, herpetiform lesions, candidiasis, vasculitis, Kawasaki-like, mucositis, drug eruptions, and necrotizing periodontal diseases.[6] Fidan *et al.* reported that the most common lesion in patients with COVID-19 was aphthous lesions, most commonly seen on the tongue, and oral lesions were found in 2/3 of the patients.[32] Tuter *et al.* reported that the most common oral symptom was dry mouth; however, oral ulcers, tongue lesions and swelling of the gingiva, tooth and implant loss, and taste disorders were found in their study conducted between February 2021-March 2021 in COVID-19 patients.[33] They also reported that patients who stated that they received periodontal treatment before COVID-19 had fewer oral complaints and symptoms compared to patients who did not receive periodontal treatment.[33] Poor oral hygiene, opportunistic infections, stress, immunosuppression, vasculitis, and increased inflammatory response were considered to be the most important predisposing factors for the onset of oral lesions in COVID-19 patients.[6]

Di Spirito *et al.* drew attention to the need to evaluate the putative role of both SARS-CoV-2 in oral lesion formation and periodontitis and the periodontal microbiome in the course of worsening and reactivations of COVID-19 in their review.[18] Besides periodontal necrotizing lesions, the most severe stages of periodontitis, have been associated with higher rates of hospitalization, need for ventilation, and mortality.[14,34] It has been hypothesized that periodontitis, poor oral hygiene, and the periodontal microbiome may be risk factors for complications and worsening of disease forms from COVID-19.[7,11,18] It seems important to systematically integrate the maintenance of oral hygiene and active periodontal treatments into interdisciplinary treatment in patients with mild to moderate COVID-19 and when possible, especially in severe cases.[1,7,11,18] It has been reported that in the control of the reservoir function of periodontal pockets for possible SARS-CoV-2, periodontal treatment together with the provision of oral antisepsis with chlorhexidine and hydrogen peroxide may contribute to reducing the risk of re-infection in patients with recovered COVID-19 as a result of balancing periodontal pathogens and viral microbial load in favor of health.[5,35]

From the first announcement days of the COVID-19 pandemic, the way of spreading from the infected patient by coughing or the aerosol environment during dental procedures has made dental professionals the most risky profession, and especially in the first periods, most dentists limited patient care only to emergency protocols determined by the ministry of health. On May 5th, 2023, WHO announced that the global impact of the COVID-19 pandemic has waned. However, the effects of the process in patients with COVID-19 who are reported as “long-COVID” or prolonged COVID and what will happen after the reactivation of the virus remain unclear.[36] With a revision in the Turkish Dental Education Core Curriculum on October 2021, COVID-19 was included in the topics of "core diseases and conditions". It could be suggested for the future to organize trainings and seminars to increase the knowledge level of graduated dentists about common systemic comorbidity factors and oral manifestations about COVID-19 and periodontitis, which have not yet been fully clarified.

Conclusions

Within limitations of the study, the outcomes highlighted that dentists, who work in the oral cavity due to the nature of their profession and are the most risky occupational group in terms of COVID-19 transmission, have insufficient awareness of the possible bidirectional interrelationships between oral health and COVID-19.

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Cumhuriyet Dental Journal, 27(2): 79-84, 2024
DOI: https://doi.org/10.7126/cumudj.1375582

Cumhuriyet Dental Journal

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

Influence of Mechanochemical Treatment and Oxygen Inhibited Layer on the Adhesion of Self-Adhesive Resin Cement to Bulk-Fill Composite Resin

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Research Article

History

Received: 15/10/2023
Accepted: 19/04/2024

ABSTRACT

Objectives: This study evaluated the shear bond strength (SBS) of self-adhesive resin cement (SARC) to bulk-fill composite resin (BFCR) following mechanical and chemical surface treatments.

Materials and Methods: The BFCR discs fabricated were divided into four groups, based on the presence or absence oxygen inhibited layer (OIL) and mechanical surface treatment, as follows; group I: OIL+no surface treatment (NT); group II: no OIL+NT; group III: no OIL+diamond abrasive (DA); and group IV: no OIL+air abrasion (AA). Each group was further divided into two subgroups based on chemical treatment using a silane agent. Following this, the SARC cylinders were bonded to the surfaces of the treated BFCR samples. SBS was evaluated for all the samples, and failure analysis was carried out. The data were analysed using an independent t-test, one-way ANOVA and post hoc Tukey test and a *p* value of <0.05 was considered to indicate statistical significance.

Results: The highest SBS was recorded in group IV (no OIL+AA) without silane application (25.66±4.49 MPa), while the lowest was observed in group I (OIL+NT) with silane treatment (0.4±0.24 MPa). Mechanical surface treatment succeeded in significantly improving the SBS, while chemical surface treatment using silane application failed to do so.

Conclusions: Mechanical surface treatment via abrasion enhanced the bonding ability of BFCR with SARC. However, OIL and chemical treatment using a silane agent did not improve the SBS.

Keywords: Air abrasion, Composite resin, Resin cement, Shear bond strength, Silane.

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How to Cite: Dutta S, Sahu SP, Arora A, Natarajan S, Parolia A, Thomas M. (2024) Influence of Mechanochemical Treatment and Oxygen Inhibited Layer on the Adhesion of Self-Adhesive Resin Cement to Bulk-Fill Composite Resin, Cumhuriyet Dental Journal, 27(2):79-84.

Introduction

Composite resins are commonly used as core build-up materials. Incrementally cured composites suffer from void incorporation and interlayer contamination.[1] In an attempt to overcome these shortcomings, bulk-fill composite resins (BFCR) have been introduced with the claim of greater depths of curing in deeper increments.[2]

Dental composites light-cured in air possess a sticky superficial layer of unreacted monomers and oligomers known as the oxygen inhibition layer (OIL).[3] The OIL forms an interdiffusion zone where materials from both sides blend to copolymerize, producing chemical bonds.[4] Reports on the effect of this layer on bond strength have been inconsistent.[3,4]

Partial adhesive restorations aimed at preserving healthy tooth structures can be bonded to composite-restored teeth using self-adhesive resin cements (SARCs). Eliminating the need for a separate etching and bonding procedure, SARC has emerged as an economical alternative with regard to both time and chair-side costs. These materials retain the mechanical properties and bonding ability of conventional resin cements.[5]

For indirect restorations to be successful, a durable bond between the luting cement and the core composite is essential. Surface contamination of the core composite by saliva and temporary luting agents diminishes its ability to foster chemical changes.[6] Mechanical and chemical surface treatments restore some of these abilities prior to the luting of indirect restorations. Various techniques, such as air abrasion, roughening with a diamond abrasive point, and silanization, have been attempted but have produced inconsistent results.[7,8]

The bonding of SARC to restorative composite resin has been inadequately probed. This study, therefore, aimed to assess the shear bond strength of SARC adhered to BFCR subjected to various surface treatments. The null hypotheses investigated were that the presence or absence of OIL, as well as mechanical and chemical

surface treatments, would not impact the bond strength of SARC to the BFCR.

Materials and Methods

Study design and approval

The *in vitro* study was conducted after obtaining approval (IEC No. 21046) from the Institutional Ethics Committee of MCODS, Mangalore, on July 11, 2021.

Sample size calculation

Referring to a prior study conducted by Ghivari *et al.*[9], which compared composites cured with OIL to those cured without OIL, the essential parameters for assessing the role of OIL in shear bond strength included a 5% alpha error, a study power of 95%, and a clinically significant difference of 2 units. Based on these parameters, the required sample size in each group was determined to be 5.

Preparation of composite cylinders

Cubic acrylic moulds (3.5x1.5x1.5 cm) housing cylindrical slots were used to fabricate forty BFCR (Tetric N-Ceram Bulk Fill, Ivoclar Vivadent, Liechtenstein) cylindrical samples with dimensions of 6 mm in diameter and 2 mm in height. With a single increment of 2 mm in depth, the BFCR was filled into the moulds, leaving a single exposed surface.

In order to form OIL, ten samples were light-cured for 45 seconds in air at a light intensity of 800 mW/cm2 (Bluephase, Ivoclar Vivadent, Liechtenstein). The remaining 30 samples were light-cured in air for 30 seconds, followed by additional anaerobic curing for 15 seconds through the application of a glycerine gel to form the OIL.

Storage and aging

All the samples were stored in artificial saliva for 7 days at 37°C. Artificial saliva used composed of 0.4gram NaCl, 1.21gram KCl, 0.0005gram Na2S.9H2O, 0.7gram NaH2PO4.2H2O and 1gram CO(NH2), with all components being dissolved in 1000 ml deionized water with pH corrected to 6.75±0.75 using 0.1 N NaOH.

Grouping

The samples were randomly divided into four groups (n=10) based on the surface treatments. The details of the materials used are described in Table 1. Figure 1 summarizes the methodology.

Group I (OIL+NT): BFCR were cured in contact with air and not subjected to mechanical surface treatment to maintain OIL.

Group II (No OIL+NT): Anaerobically cured BFCR not subjected to mechanical surface treatment.

Group III (No OIL+DA): Anaerobically cured BFCR was roughened using a diamond bur (TF-12 Diamond Abrasive Point- medium grit, SS White, USA) with a slow-speed handpiece (NSK Ltd., Japan) for 10 seconds.

Group IV (No OIL+AA): Anaerobically cured BFCR treated with air abrasion and white alpha aluminium oxide particles for 15 seconds.

Each group was further divided into two subgroups (n=5): (A) no chemical treatment with a silane agent and (B) chemical treatment with a silane agent (Monobond N, Ivoclar Vivadent, Liechtenstein).

To obtain self-adhesive resin cement (SARC) cylinders, polyethylene moulds with a diameter and height of 3 mm and 4 mm, respectively, were positioned over the treated composite resin surfaces, into which the SARC (SpeedCem Plus, Ivoclar Vivadent, Liechtenstein) was injected and light-cured for 30 seconds.

The samples were stored a second time in artificial saliva for three days until shear bond strength (SBS) analysis commenced.

Shear bond strength testing

A universal testing machine (Instron Corporation, Canton, MA) at a crosshead speed of 0.5 mm/min was used to test samples for SBS after they were positioned into a jig. The strengths were calculated and converted to megapascal (MPa) by dividing the failure load expressed in Newtons (N) by the bonded area per square millimetre (mm^2).

Analysis of the failure modes

Fracture analysis of the adhesive surfaces was performed under a stereomicroscope at 20x magnification (Stereo Star Zoom-570, Reichert, New York, USA), and the failures were categorized as cohesive (fracture within the BFCR or SARC), adhesive (fracture at the adhesive interface between the BFCR and SARC) or mixed (simultaneous occurrence of adhesive and cohesive failures).

Statistical analysis

The SBS values obtained were tabulated and analysed using software (SPSS Version 20, IL, USA). Independent t-test was used to evaluate the effect of silane application in various subgroups. One-way ANOVA and post hoc Tukey tests were used to determine the level of significance among the experimental groups. A p value of <0.05 was considered to indicate statistical significance. Additionally, the chi-square test was performed to assess the significance of the difference in the type of failure among the various groups.

Table 1: *Materials used in the study and their description*

Materials	Manufacturer details	Composition	Usage
Air abrasion unit	PrepStart air abrasion system, Danville, San Ramon, CA, USA.	-27 micrometre white alpha aluminium oxide particles	-Operated at 80 psi pressure. -The composite surfaces to be bonded were air abraded with the alumina particles in circular sweeping motion for 15 seconds per sample.
Bulk-fill composite	Tetric N-Ceram Bulk Fill, Ivoclar Vivadent, Schaan, Liechtenstein.	-Dimethacrylates (21% by weight): Bis-GMA, Bis-EMA and UDMA -Polymer filler: 17.0 % by weight -Barium glass filler, Ytterbium trifluoride, Mixed oxide: 61.0 % by weight -Additive, Initiators (Ivocerin, Acyl phosphine oxide, Camphoroquinone), Stabilisers, Pigments: <1.0 % by weight	-Composite was light-cured in a single increment of 2 millimetres depth. (According to the manufacturer, can be cured in increments of up to 4mm.) -Light activation was performed for 40 seconds.
Silane	Monobond-N, Ivoclar Vivadent, Schaan, Liechtenstein.	-Alcohol solution of: -Silane methacrylate, -Phosphoric acid methacrylate, and -Sulphide methacrylate	-Composite surfaces were thoroughly rinsed with water spray and dried with water and oil-free air. -Monobond-N was applied onto the surfaces to be bonded using a microbrush and allowed to react for 60 seconds. -It was then be dispersed with a strong stream of air.
Self-adhesive resin cement	SpeedCem Plus, Ivoclar Vivadent, Schaan, Liechtenstein.	-Monomer matrix: Dimethacrylates and acidic monomers. -Inorganic fillers (40% by volume, size 0.1-7µm): barium glass, ytterbium trifluoride, co-polymer and highly dispersed silicon dioxide. -Additional contents (<1%): initiators, stabilisers and colour pigment	-For each application, a new automix tip was placed on the double syringe. -SpeedCem Plus was extruded from the automix syringe, the desired quantity applied directly onto the composite surface. -It was then light-cured for 30seconds with a light intensity of 800mW/cm².

Bis-GMA: bisphenol A-glycidyl methacrylate, Bis-EMA: Ethoxylated bisphenol A dimethacrylate, UDMA: Urethane Dimethacrylate

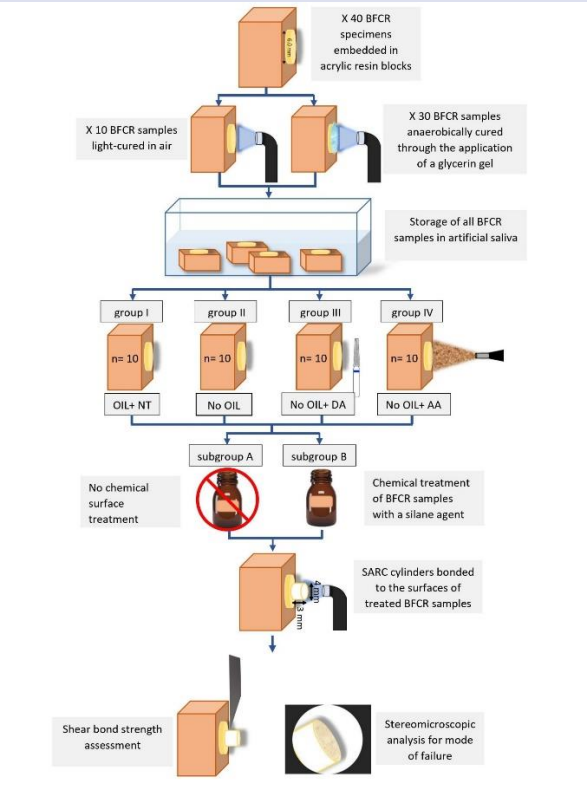

Figure 1: Schematic diagram of the methodology

Results

Shear bond strength test (SBS)

The highest SBS value was observed in Group IV-A (25.66±4.49 MPa), while the lowest was noted in Group I-B (0.4±0.24 MPa). A comparison of the SBS between the subgroups in each of the major groups by one sample t-test revealed statistically significant differences only for Group I (p = 0.038) (Table 2).

The SBS of all the subgroups, when compared using one-way ANOVA, demonstrated a statistically significant difference (p <0.001). A post hoc Tukey test revealed that the differences in SBS between groups IA, IB, IIA, and IIB were not statistically significant. Similarly, groups IIIA, IIIB, IVA, and IVB were not statistically significant (p >0.05). However, groups IA, IB, IIA, and IIB demonstrated significantly lower SBS than IIIA, IIIB, IVA, and IVB (p <0.001). Thus, irrespective of the subdivision, the mechanically treated samples (Group III and IV) revealed statistically significantly higher SBS than the groups where no surface mechanical alteration was done before SARC placement (Group I and II) (Table 2).

Analysis of the mode of failure

Kappa statistics demonstrated excellent inter-observer reliability (κ=0.911). The chi-square test demonstrated a significant difference in the mode of failure among the groups (χ^2=25.846, p =0.027). The samples in groups I and II exhibited exclusive adhesive failure. Groups III and IV displayed predominantly mixed failures. Cohesive failure was noted to be the least common occurrence. (Figure 2)

Table 2: Descriptive and analytical data of shear bond strength (MPa) values

Group	Subgroup	Range	Mean ± SD*	t	p value
Group I	A (No Silane)	1.71 to 8.95	4.59±3.09 ^{A}	3.025	0.038
(OIL+ NT)	B (Silane)	0.21 to 0.73	0.4±0.24 ^{A}		
Group II	A (No Silane)	0.78 to 5.27	3.11±1.62 ^{A}	0.45	0.666
(No OIL+NT)	B (Silane)	1.28 to 3.78	2.69±1.04 ^{A}		
Group III	A (No Silane)	15.45 to 25	20.64±3.92 ^{B}	1.475	0.178
(No OIL+DA)	B (Silane)	21.73 to 26.18	23.45±1.7 ^{B}		
Group IV	A (No Silane)	20.39 to 30.04	25.66±4.49 ^{B}	1.926	0.106
(No OIL+AA)	B (Silane)	18.39 to 23.58	21.41±2.06 ^{B}		

OIL: Oxygen inhibited layer, NT: no surface treatment, DA: diamond abrasive, AA: air abrasion, t= Independent t-test value; p= Probability value
* Different superscript letters indicate statistical significance within all the sub-groups (p <0.05).

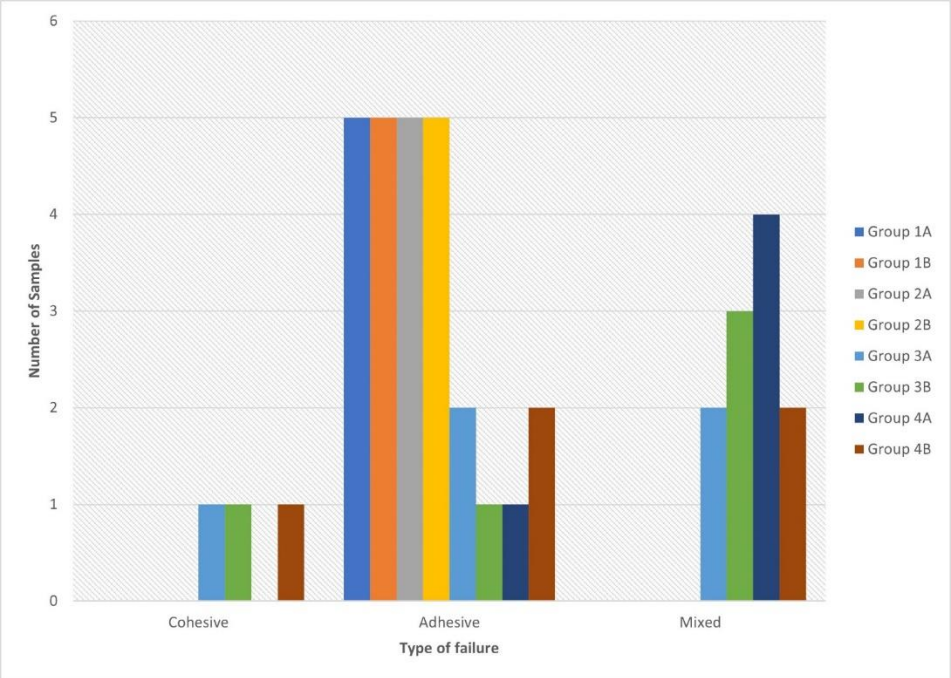

Figure 2: Distribution of failure modes in specimens from various groups

Discussion

The presence of unreacted acrylates in the oxygen inhibition layer (OIL) led to the assumption that this layer is a prerequisite for promoting bond formation between aged and fresh composite resins.[10] In this study, there were no significant differences between the bond strengths measured in the presence or absence of OIL, even without mechanical surface treatment of the BFCR. Hence, the first part of the null hypothesis had to be accepted. This finding implies that the presence of OIL is essential for the bonding of BFCR to SARC. The depletion of the photoinitiator camphoroquinone in the OIL may account for this difference, as may the presence of acidic monomers in SARC, rendering it incompatible with the OIL.[5,9,10]

The insufficient bond strengths observed in the groups not mechanically surface-treated may be an outcome of artificial saliva aging. Water sorption induces hydrolytic degradation in the resin matrix and eventual inactivation of the matrix. The presence of TEGDMA molecules in resin-based composites is largely associated with water sorption. These factors heighten the susceptibility of the BFCR to hydrolytic degradation, robbing its ability to form a clinically acceptable bond with the luting agent.[11,12] Feeble bonding between the BFCR and SARC in the samples of these two groups is also reflected in adhesive failure being the sole prevalent mode of failure here.

The deposition of a whitish precipitate on the BFCR samples may also have contributed to the decrease in bond strength. These fissured, semi-transparent precipitates appeared on the surface of the BFCR after a week of immersion in artificial saliva. Söderholm *et al.*[13] reported the presence of an unexpected whitish-yellow semi-transparent precipitate on the surface of composites stored in artificial saliva. A similar precipitate was detected by Gregson *et al.*[12] Using scanning electron microscopy and inductively coupled plasma atomic emission spectrometry, they concluded that the precipitate consisted of calcium and phosphate ion deposits. The precipitate detected in the present study is likely of a similar nature, and when left undisturbed, an immaculate bond between the BFCR and SARC was impeded.

Chemical bonding of composite resins to SARC occurs chiefly through the bonding of methacrylate monomers. The reduced availability of unreacted monomers on the cured composite surface may hinder the bonding mechanism.[14,15] Saliva contamination in the oral environment causes the leaching of unreacted monomers. Surface treatment of aged resin composites removes the saliva-altered superficial layer, creating surface irregularities to improve the available area for the cement to bond.[16]

Air abrasion, through nonselective degradation of the composite resin, creates an irregular surface enhancing micro-retentive features in the form of grooves and pits. This helps fortify the bond with the resin cement.[17] In the present study, air abrasion with 27 µ aluminium oxide particles without salinization of the composite surface yielded the highest bond strength. Previously conducted studies assessing the bond strength of repaired composites and that between a composite resin and luting cement corroborate these results.[9,16-19] Silane treatment of air-abraded composite surfaces, though insignificant, did not significantly degrade the bond strength. This result is consistent with that of a prior study, and this could be attributed to the lower inorganic content of the bulk-fill composite as well as the additional components of the multimode silane coupling agent.[20]

Treatment with a diamond abrasive point did not significantly differ between SBS from the air-abraded group, a finding supported by earlier studies.[8,15] This difference may be due to the similar micro-retentive features and mechanical interlocking produced by both techniques. Both treatments were highly effective at potentiating the bonding between the BFCR and SARC; hence, the second part of the null hypothesis was rejected. In the mechanically surface-treated groups, a rise in mixed fractures was observed at the interface of the two materials, accompanied by few cohesive failures. This finding supports the precedence of mechanically surface-treating the BFCR before it binds to the SARC.

Silane coupling agents are bifunctional molecules capable of promoting chemical adhesion between two dissimilar materials.[21] Studies exploring the efficacy of silane have offered no congruent verdicts. In the present study, no significant changes in bond strength could be discerned following surface treatment with a silane agent. The third aspect of the null hypothesis therefore cannot be rejected. Moreover, the OIL+NT group exhibited a significant reduction in bond strength following silane application. This result is concordant with reports from a prior study by Guiterrez *et al.*[22]

Silane coating and air drying of the composite surface create two distinct layers: the innermost chemisorbed layer, which is siloxane bonded to the composite surface, and the outer physiosorbed layer, which contains few siloxane bonds. Only the former contributes to the coupling mechanism, and the presence of the latter in excess may prove detrimental to the bonding procedure.[23] A thick, multiphase interfacial layer formed due to silane treatment impairs the intimate interaction of the methacrylate monomers of the SARC with the polymerized composite resin polymers.[22] The precipitate deposited on the composite surface during storage in artificial saliva might have consolidated this interfacial layer, further weakening the bond between the BFCR and SARC in mechanically surface-treated groups.[12,13] The present study demonstrated that chemical surface treatment alone fails to achieve satisfactory bond strength. Even as an adjunct to mechanical means, it does not prove beneficial and can be omitted.

Despite attempts to standardize all the laboratory techniques employed in this study, we cannot use duplicate the *in vivo* conditions. To predict the long-term behaviour of the materials tested, the approaches adopted should mimic oral conditions as closely as possible. Contamination of the BFCR samples using temporary luting agents prior to any surface treatment and adopting thermocycling as the aging procedure will help better align the results obtained with an actual clinical situation.

Conclusions

Within the limitations of the current study, the following conclusions can be drawn:

- The presence or absence of an oxygen inhibition layer does not impact the bond strength of bulk-fill

composite resins (BFCR) to self-adhesive resin cement (SARC).

- Mechanical surface treatment of the BFCR enhanced its bonding ability with the SARC.
- Chemical surface treatment of BFCR using a silane agent does not improve the bond strength of the material to the SARC.

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Cumhuriyet Dental Journal, 27(2): 85-91, 2024
DOI: https://doi.org/10.7126/cumudj.1383141

Cumhuriyet Dental Journal

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

Evaluation of Plain Ultrasound Therapy Versus Diclofenac Phonophoresis for the Management of Temporomandibular Joint Disorders

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Research Article

History

Received: 31/10/2023
Accepted: 08/04/2024

ABSTRACT

Objective: Temporomandibular joint disorders (TMD) are one of the most common causes of Chronic orofacial pain. Management of TMD includes various invasive and non-invasive methods. The present study was undertaken to compare the efficacy of plain ultrasound therapy and 1% diclofenac gel phonophoresis in the management of TMDs.

Materials and Methods: 50 participants with pain in the TMJ region, falling in Research Diagnostic Criteria (Group I and II) for TMJ disorders and in the age group of 18-40 years were included in the study. Participants were divided into 2 groups by simple randomization. Group A comprised of 25 participants who received plain Ultrasound therapy, while Group B comprised of 25 participants who received Diclofenac gel Phonophoresis. All the study participants were asked to refrain from consuming any other analgesics and muscle relaxants until the completion of six sessions over a period of two weeks. Pre and Post treatment assessment of the participants was carried out using visual analogue scale (VAS) for TMJ pain, Maximum Mouth opening (MMO) and Helkimo clinical dysfunctional Index (HI). Recurrence within a period of 3 months was recorded in both groups.

Results: Intergroup comparisons of VAS, HI and MMO between pre and post treatment were analysed using Independent t-tests. The difference in the mean pre (T1) and post (T2) treatment pain VAS scores and Helkimo index (HI) in both the groups was statistically significant. Group B showed statistically significant reduction in the VAS scores, HI compared to Group A. There was no statistically significant difference in the recurrences among the two groups.

Conclusion: The findings of present pilot study showed that both the methods were effective, however 1% Diclofenac phonophoresis was more effective than plain ultrasound therapy with regard to reduction of pain and functional ability of the TMJ.

Keywords: Temporomandibular joint disorders, Ultrasound therapy, Phonophoresis.

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How to Cite: Asan MF, Hegde S, Ajila V. (2024) Evaluation of Plain Ultrasound Therapy Versus Diclofenac Phonophoresis for the Management of Temporomandibular Joint Disorders , Cumhuriyet Dental Journal, 27(2):85-91.

Introduction

Temporomandibular joint (TMJ) is one of the most complex synovial joint formed by the mandibular condyle and its corresponding temporal cavity. TMJ has a vital role in monitoring the mandibular movements thereby controlling various essential daily tasks such as speech and mastication.[1] Temporomandibular joint disorders (TMD) are one of the most common causes of chronic orofacial pain. According to the American Academy of Orofacial Pain (AAOP), TMD is a collective term given for a number of clinical problems which involve the masticatory muscles, the temporomandibular joints and associated structures.[2] Literature evidence shows that TMD affects approximately 10% to 15% of adult population.[3] The etiology of these disorders is complex and their management includes various invasive and non-invasive methods. Conservative management options for TMD treatment include occlusal therapy, physical therapy, oral pharmacotherapy, orthodontic treatment.[4]

Oral pharmacotherapy is the most commonly used treatment for TMDs. Non-steroidal anti-inflammatory drugs (NSAIDs) and muscle relaxants are the frequently used drugs for pharmacotherapy, but they have significant adverse effects.[5] Physical therapy modalities such as manual therapy, biofeedback, ultrasound therapy and transcutaneous electrical nerve stimulation (TENS) are also widely accepted non-invasive modalities for the management of TMDs.[6] Therapeutic ultrasound utilizes ultrasonic waves with vibrations above 16,000 vibrations/second or 16 Hertz. It is known to increase blood flow, permeability, and promote healing of tissues. It also has the ability to reduce pain and muscle spasms by increasing the extensibility of collagen fibres.[7,8] Phonophoresis is a treatment modality that utilizes ultrasound waves to aid the percutaneous transport of drug molecules to aid in better absorption.[9] Established proofs need to be included in the literature regarding the beneficial effects of phonophoresis in TMDs.

Though there are various non-invasive modalities available in the literature for the management of TMDs, there is a scarcity of literature comparing their efficacy in the management of TMDs. The primary outcome of management of TMDs is pain relief and improved functional ability. Hence, the present study was undertaken to compare the efficacy of plain ultrasound therapy and 1% diclofenac gel phonophoresis in the management of TMDs.

Materials and Methods

Our study was approved by the Institutional Research and Ethical Committee (Certificate No. ABSM/E/123/2021) and followed the principles set forth in the Helsinki Declaration.

The study was carried out in the Orofacial Pain Clinic of a private dental hospital in India. The present randomised control study comprised of 50 participants in the age group of 18-40 years, who reported with complaint of pain in the TMJ region. All patients were evaluated by two trained Oral Medicine and Radiology specialists with more than 10 years of clinical experience. Panoramic radiograph and TMJ views were taken to evaluate degenerative changes in the TMJ. Participants with degenerative changes such as flattening, surface erosions, Ely cyst, sclerosis, osteophytes, and loose joint body in panoramic radiograph and TMJ view were excluded from the study. All the relevant data was recorded in the study proforma. Any contradictions that arose in the evaluation of research topics were resolved by discussing among the two specialists.

TMJ disorders were evaluated according to the Research Diagnostic Criteria (RDC/TMD)[10] in the study. The Research Diagnostic Criteria (RDC) categorise TMD into 3 groups. They are as follows: [10]

Group I: Muscle disorders
a) Myofascial pain
b) Myofascial pain with limited opening,
Group II: Disc Displacements (DD)
a) DD with reduction
b) DD without reduction with limited opening
c) DD without reduction without limited opening,
Group III: Other common Joint disorders:
a) Arthralgia
b) Osteoarthritis
c) Osteoarthrosis

Participants with a history of TMJ pain for more than 3 months, participants falling in Research Diagnostic Criteria Group I and II for TMJ disorders were included in the study. The exclusion criteria for the study consisted of the following:

- Participants with history of recent trauma, open facial wounds, cardiac pacemakers, metal implants in the craniofacial region.
- Participants with a history of systemic disorders and syndromes
- Participants with pure arthrogenic pain (RDC/TMD Group III), patients with known disease such as rheumatoid arthritis, ankylosing spondylitis, systemic lupus, gout, reactive arthritis, fibromyalgia
- Participants with features of degenerative diseases such as flattening, surface erosions, Ely cyst, sclerosis, osteophytes, and loose joint body in the panoramic radiograph and TMJ views.
- Participants with associated odontogenic pain.
- Participants who had been previously treated with ultrasound therapy without any clinical improvement were also excluded from the study.

Study sample size calculation

Based on Standard deviation of 0.86 in group I, Standard deviation of 1.21 in group II, Mean difference of 1.22, Effect size is 1.17874396135266, Alpha Error is 0.5(%), Power 90% for two sides test the required sample size per group is 25.[11] This was calculated using Master software version 2.

Study participants who fulfilled the inclusion criteria and were willing to take part in the study were explained about the study procedures in detail and written informed consent was obtained before commencement of the intervention. Participants were categorized into 2 groups based on simple random sampling by independent postgraduate residents. Group A comprised of 25 participants who received plain Ultrasound therapy, while Group B comprised of 25 participants who received 1% Diclofenac gel (Voveran® Emulgel®) Phonophoresis. All the study participants were asked to refrain from consuming any other analgesics and muscle relaxants until the completion of six sessions.

Electroson–709 (Techno med Electronics) ultrasound device was used for performing the ultrasound therapy and phonophoresis. The pre-auricular skin of the affected TMJ region was cleansed prior to the therapy. A layer of Ultrasound gel was evenly spread over the transducer head and the application was done on Continuous mode in slow circular motions with a frequency of 1 MHz, intensity of 1.3 W/cm² for 10 minutes for one session. Three such sessions weekly for a period of 2 weeks was given. For the phonophoresis group (Group B), Ultrasound gel along with 1% Diclofenac gel (in the ratio of 1:1) was spread evenly over the transducer head and the application was done using the same parameters and duration. Figure 1 shows ultrasound device and clinical application procedure. During each follow up visit, patients were asked about compliance with the instruction to refrain from consuming any other analgesics and muscle relaxants and response were recorded. All the study participants were informed to report if they experience any adverse effects pertaining to the treatment provided.

The visual analogue scale (VAS) and Helkimo dysfunctional clinical index were used before and after every treatment session to monitor changes in intensity of pain and efficacy of the treatment.

The participants were assessed in terms of TMJ Pain, Maximum Mouth opening, Helkimo clinical dysfunctional Index and recurrence within a period of 3 months. Pain was measured using VAS in a 0-to-10-point scale. VAS was used to assess subjective ratings of the subject's pain intensity.

Maximum Mouth opening (MMO) was measured as using a calibrated vernier calliper with 1mm precision and the inter incisal distance was noted. Helkimo clinical dysfunction index (HI) was recorded based on the clinical examination of TMJ.

Helkimo clinical dysfunction index (HI) has the following signs for assessment: limited movement, limitation of TMJ

movement, muscle pain, TMJ pain and pain during jaw movements. Patients were given a score of 0 points for absence of symptoms, 1 point for mild pain or dysfunction, and 5 points for severe pain or dysfunction.[12-14]

The pre and post treatment assessments were performed by oral physicians who were blinded about the intervention provided to the subject.

Statistical Analysis

The data obtained were tabulated and expressed in mean ± standard deviation. Statistical analysis was performed using Statistical Package for the Social Sciences - Version 21 (SPSS Inc., Chicago, IL, USA). Intra-group differences for pain between pre-treatment and post treatment were analysed using Wilcoxon rank test, while intergroup comparisons of VAS, HI and MMO between pre and post treatment were analysed using independent t-tests. Chi square test was used to compare the recurrences among the groups. P value< 0.05 was considered to be statistically significant.

Results

The study constituted of 50 subjects, 25 participants in group A and 25 participants in group B. Out of which 17 were males and 33 were females. Group A had 10 males and 15 females and Group B had 7 males and 18 females. Minimum age of the participants was 18 years and maximum age was 40 years. Demographic details of the study participants were given in Table 1. The mean age of the study participants in group A was 29.32±9.8 years and in Group B was a 29.84±11.28 year.

Group A participants received plain Ultrasound therapy and Group B participants who received 1% Diclofenac gel phonophoresis. None of the study participants reported adverse effects pertaining to the treatment provided.

Subjective pain assessment by VAS showed decreased pain after treatment provided in both the groups. There was a statistically significant difference in mean pre (T1) and post (T2) treatment in both the groups (p<0.001) (Table 2). The pretreatment VAS in Group A and Group B was 7.24 and 7.76, while it reduced to 2.80 & 1.56 respectively post treatment. There was statistically significant reduction in the VAS (T2-T1) in Group B when compared to Group A (p=0.001) (Table 3, Figure 2).

Helkimo Dysfunctional Index was recorded in both groups before and after treatment sessions. There was a statistically significant difference between mean pre (T1) and post (T2) treatment in both the groups (p<0.001) (Table 2). The pretreatment HI in Group A and Group B was 5.28&5.84, while it reduced to 2.28 and 1.84 respectively post treatment. There was statistically significant reduction in the HI (T2-T1) in Group B when compared to Group A (p=0.027) (Table 3, Figure 3).

Maximum Mouth Opening was recorded in all study participants pre and post treatment. The pre-treatment MMO in Group A and Group B was 40.04 & 39.6, while it reduced to 42.76 & 43.32 respectively post treatment. There was a statistically significant difference between the mean pre (T1) and post (T2) treatment in both the groups (p<0.001) (Table 2). There was statistically significant increase in the maximum mouth opening (T2-T1) in Group B when compared to Group A (p = 0.005) (Table 3, Figure 4).

The participants were followed up for a period of 3 months after the intervention for the recurrence of the pain and functional limitation of the TMJ. Four (16%) participants in Group A and one (4%) subject in Group B reported with recurrence. But there was no statistically significant difference in the recurrences among the two groups (P value 0.157). Comparison of recurrence among both the groups shown in Table 4.

Table 1: Demographic details of the participants included in the study

	Group – A Ultrasound Therapy	Group – B Diclofenac Phonophoresis
Number (n)	25	25
Age (in years)	Minimum = 19 Maximum = 39 Mean = 29.32	Minimum = 18 Maximum = 40 Mean = 29.84
Gender n (%)	Males = 10 (40%) Females = 15 (60%)	Males = 7 (28%) Females = 18 (72%)

Table 2: Intra group Comparison between two groups

T2-T1		Group	Mean	Std. Deviation	P value *
VAS	A	Pre (T1)	7.24	1.899	< 0.001
		Post (T2)	2.80	1.500	
	B	Pre (T1)	7.76	1.090	< 0.001
		Post (T2)	1.56	1.083	
HI	A	Pre (T1)	5.28	1.620	< 0.001
		Post (T2)	2.28	1.242	
	B	Pre (T1)	5.84	1.434	< 0.001
		Post (T2)	1.84	1.027	
MMO	A	Pre (T1)	40.04	2.776	< 0.001
		Post (T2)	42.76	3.031	
	B	Pre (T1)	39.60	3.175	< 0.001
		Post (T2)	43.32	2.982	

VAS : visual analogue scale , MMO: Maximum Mouth opening , HI: Helkimo clinical dysfunctional Index , * : symbol represents statistically significant value

Table 3: Inter group Comparison between two groups

T2-T1	Group	Mean	Std. Deviation	P value *
VAS	A	4.44	1.635	0.001
	B	6.20	1.848	
HI	A	3.00	1.154	0.027
	B	4.00	1.870	
MMO	A	2.72	1.027	0.005
	B	3.72	1.061	

Table 4: Comparison of recurrence among both the groups

	Group – A Ultrasound Therapy	Group – B Diclofenac Phonophoresis	P value
Recurrence within 3 months n (%)	4 (16%)	1 (4%)	0.157

Figure 1: Clinical image showing instrumentation (A,B) and application procedure(C).

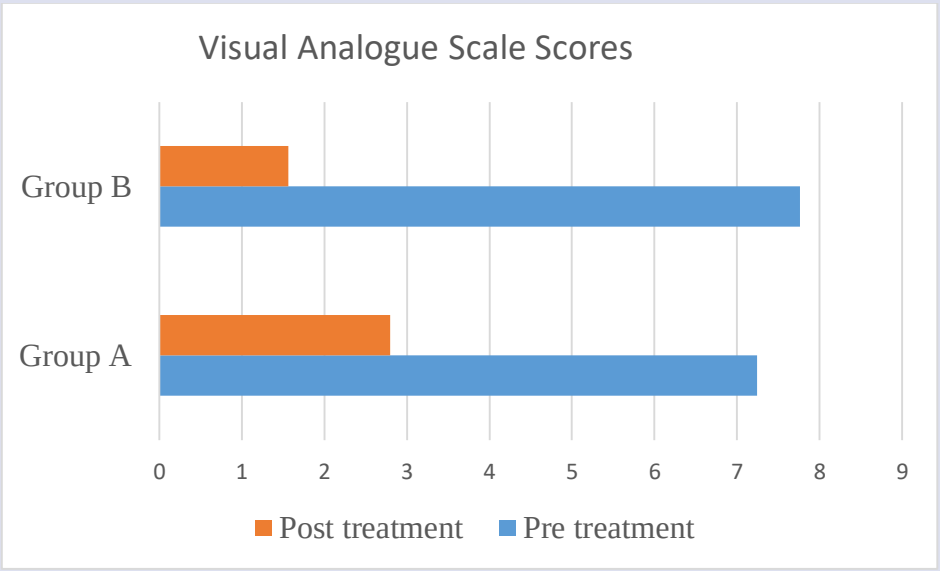

Figure 2: Mean Pre and Post treatment VAS score of both the groups

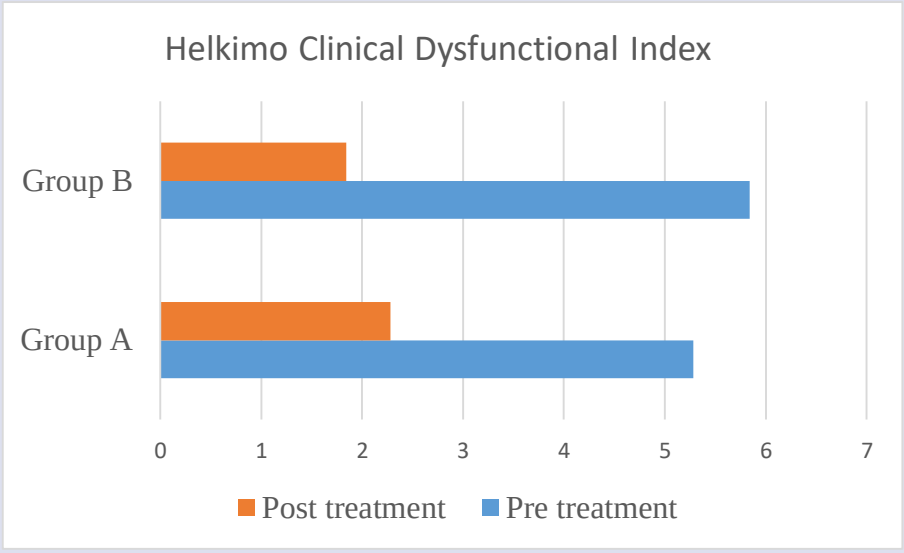

Figure 3: Mean Pre and Post treatment HI value of both the groups.

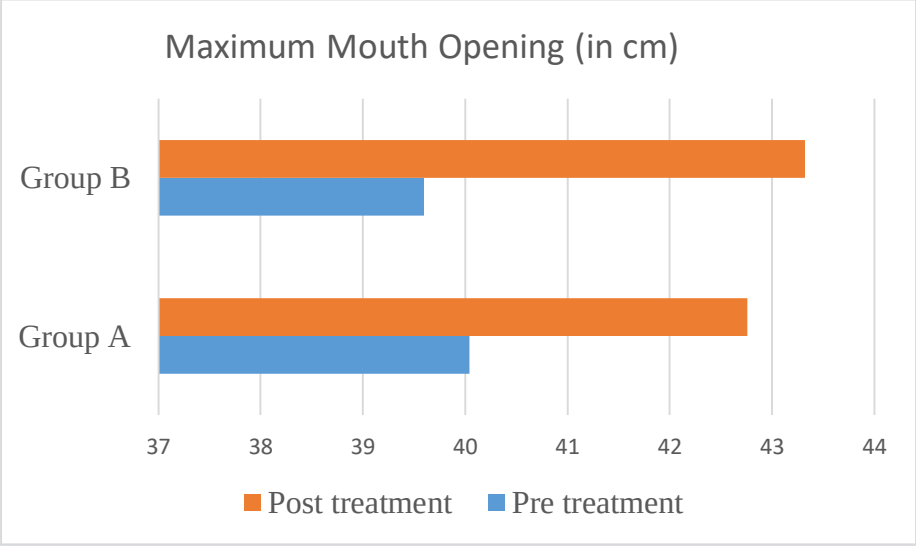

Figure 4: Mean Pre and Post treatment Maximum Mouth Opening of both the groups.

Discussion

Temporomandibular joint disorders may present with various signs and symptoms such as pain, joint noises, deviation of the jaw, limitation in the range of motion etc. Present study involved patients reporting with TMDs within the age range of 18-40 years. In the present study, the mean age of participants with TMDs was 29.5 years. A Study by Sachdeva *et al*. also found TMD to be more prevalent in the age group of 17–26 years of age.[14] Literature evidences show that the peak incidence of TMDs occur in the age group of 20-40 years.[3] We observed a female predilection in our study that can be attributed to behavioural, hormonal, and constitutional variations in females. Various studies have reported female predilection of TMDs, similar to our study.[14-17]

Pain is the foremost problem associated with TMD and it is the major reason for patients to seek medical care for TMDs.[3] The primary aim in the management of any TMD is to provide pain relief and to improve the functional ability.[18]

A systematic review assessed the efficacy of topical interventions in pain reduction and other secondary outcomes associated with TMD and reported that evidence is insufficient to support the use of topical nonsteroidal anti-inflammatory drug (NSAIDs) and capsaicin, Threraflex-TMJ, bee venom, Ping On, and cannabidiol. They recommended additional studies to validate the results.[19]

Ultrasound therapy can aid in the alleviation of pain and serve as a delivery medium for topical drugs. There are various advantages of application of ultrasound therapy in the management of TMDs, such as the lack of invasiveness and elimination of the systemic administration. It is also well tolerated by the patients, which makes ultrasound a versatile tool in the management of various musculoskeletal conditions.[20] Hence the present study used Ultrasound therapy for management of TMDs. Various drugs such as anti-

inflammatory drugs, corticosteroids such as hydrocortisone, dexamethasone, salicylates, anesthetics such as lidocaine, can be delivered percutaneously by the application of Ultrasound.[21] Diclofenac gel was used in the present study for phonophoresis.

A recent report stated that phonophoresis is a valued modality in physiotherapy, which has diverse applications and has demonstrated clinical efficacy in various musculoskeletal and inflammatory conditions. They listed various patents available related to phonophoresis in their report.[22]

Assessment of pain and pain related disability is of paramount importance in evaluation of TMD patients.[23] In our study, we evaluated the efficacy of treatment by assessing the pain, clinical dysfunction and MMO. Pain is a subjective sensation experienced by the patient. There are various qualitative and quantitative methods to assess pain.[24] A systematic review by Hjermstad *et al*[25] recommended the use of unidimensional pain scales for the assessment of pain intensity. This includes the Numerical Rating Scale, Verbal Rating Scale and Visual Analogue Scale (VAS).[25] In our study, we evaluated the pain intensity using VAS, which is easy to record and a comparable method to assess the pain. Various other studies have also used VAS for measurement of TMJ related pain.[25-28] Assessment of dysfunction associated with TMD is another important factor that has been evaluated. Helkimo Clinical Dysfunction Index is a simple, swift and a reliable method to assess the limitation of motion, pain and joint function. According to Alonso-Royo *et al*., Helkimo Clinical Dysfunction Index is a suitable and valid diagnostic method for temporomandibular joint disorders.[29]

In the present study, participants in both the groups showed considerable reduction in pain and dysfunction along with improvement in mouth opening. Rai *et al*. found ultrasound therapy to be effective in reducing TMD associated myofascial pain.[7] Various other studies have also found ultrasound to be beneficial in the management of pain and in improving mouth opening, similar to our findings.[4,7,30]

[27] Topical applications of drugs can induce allergic reactions in hypersensitive individuals; hence a skin testing is mandatory before phonophoresis. Our patients did not report any adverse reactions. Apart from NSAIDs, corticosteroids can also be safely administered using phonophoresis for the management of TMDs.[28]

The main goal of management of TMJ disorders is alleviation of pain. The pain associated with TMD is proportional to the deterioration of functional ability of the joint.[33] Hence, effective management of pain can reduce the dysfunction associated with TMDs. Though ultrasound therapy and phonophoresis are effective in the symptomatic management of TMDs, we noted recurrence in 16% of participants in the therapeutic ultrasound group and in 4% of participants in the phonophoresis group. Though the symptomatic recurrence is less in the phonophoresis group, it was not statistically significant. The variations in the recurrences observed may be attributed to the multifactorial nature of the disorder. Wieckiewicz M *et al* mentioned that though physical therapy modalities are considered as the primary therapeutic choice for the management of TMD pain, the treatment should also be directed towards the elimination

Ultrasound waves penetrate the tissues and produce vibrations at the molecular level generating thermal energy. The local increase in thermal energy aids in vasodilatation, alteration of cellular permeability and promotion of cellular metabolism. This results in utilization of inflammatory mediators, yielding pain relief and decrease in joint stiffness which in turn leads to increase in mouth opening and reduced joint dysfunction.[31]

We used 1% diclofenac gel in conjugation with ultrasound to provide phonophoresis. There are various drugs that have been used to as analgesic for TMD phonophoresis. Fernandez-Cuadros *et al*. in their study used 10% diclofenac, while Vijayalakshmi *et al* and Ramakrishnan et al. used aceclofenac.[11,27,32] In our study, there was a significant decrease in the post treatment VAS and dysfunctional index, with improved mouth opening when compared to the baseline in the phonophoresis group. Vijayalakshmi *et al*. in their clinical trial, reported improved mean maximum mouth opening with reduction in scores of VAS and Helkimo dysfunction index in aceclofenac phonophoresis group as compared to topical application of acelcofenac.[32] Our study results are in collaboration with Ramakrishnan *et al*. study which reported aceclofenac phonophoresis to be superior to plain ultrasound therapy in pain management of TMDs.[11]

The improved efficacy of diclofenac phonophoresis group can be attributed to the anti-inflammatory and analgesic effect of the NSAID that contributes in the reduction of inflammation of the joint.[26] Since, Diclofenac is not metabolized in the skin; it can be transported transdermally with the aid of ultrasound. Phonophoresis can provide a safe absorption of the drug without the need for oral administration which may be accompanied by various adverse effects. It can also serve as a painless, non-invasive substitute to injections for the management of inflammatory musculoskeletal conditions.[21,26-27] Our finding is also in accordance with a study by Fernandez-Cuadros *et al*. who reported diclofenac phonophoresis to be effective in the management of TMDs.

of possible etiology to achieve long term results without recurrences.[34]

Limitations of the present study was unequal gender distribution in both the groups. Due to randomization equal gender distribution in two study groups was not considered in the present study.

Conclusions

Therapeutic ultrasound and Phonophoresis are effective physical therapy modalities for the management of temporomandibular joint disorders. Present study results showed that 1% Diclofenac phonophoresis was more effective than plain ultrasound therapy in terms of reduction of pain and improving the functional ability of the TMJ. Though our study results emphasize the superiority of Diclofenac phonophoresis over plain therapeutic ultrasound in the management of temporomandibular joint disorders, further large-scale studies comparing the efficacy of phonophoresis using drugs for the management of TMDs have to be undertaken.

Conflicting interests

The authors declare no conflicts of interest

Source of Funding

The authors received no financial support for the research and/or authorship of this article

Ethic approval

Our study was approved by the Institutional Research and Ethical Committee (Certificate No. ABSM/E/123/2021) and was performed abiding the principles set forth in the Helsinki Declaration.

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Cumhuriyet Dental Journal, 27(2): 92-97, 2024
DOI: https://doi.org/10.7126/cumudj.1386426

Cumhuriyet Dental Journal

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

The Relationship between Pont, Bolton Analysis, DMF Index and the Severity of Malocclusion at SDN Gambut 10, Banjar Regency, South Kalimantan, Indonesia

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Research Article

History

Received: 08/11/2023
Accepted: 26/04/2024

ABSTRACT

Background: Malocclusion is abnormal relationship between upper and lower jaw. Malocclusion can lead to not only facial aesthetics dissatisfaction, difficulty in speaking, chewing and swallowing, but also temporomandibular joint disorder and orofacial pain. There are several factors that can cause malocclusion, such as: genetics (hereditary), overall health history, oral habit and local factors (e.g.: misplaced tooth germ, agenesis, and caries). These factors can be observed by measuring jaw length and width, jaw discrepancy as well as caries severity level.

Purpose: To analyze the relationship between some etiology of malocclusion and the severity of malocclusion.

Methods and materials: This was a cross-sectional observation research to analyze the severity of malocclusion and its possible cause of etiology. Alginate impression was taken on all 104 students in grade 4-6, then poured with type III dental plaster to create study models. Several measurements were made on the models: premolar and molar width (Pont's analysis), tooth size discrepancy (Bolton's analysis), and jaw discrepancy. The severity of malocclusion was determined based on ICON index, while the severity of caries was categorized using DMF index. The data obtained were displayed in the form distribution and percentage based on gender, then Chi-square test was performed to analyze the relationship between the variables.

Results and Conclusion: The characteristics of malocclusion in grade 4-6 students at SDN Gambut 10 are mild level of malocclusion with constriction of both upper and lower jaw. There is correlation between constriction in molar region and lower jaw crowding with the severity of malocclusion. Malocclusion occurs due to various etiological factors, thus its severity cannot be determined by some factors alone.

Keywords: Malocclusion, ICON, Etiology of Malocclusion

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How to Cite: Budipramana M, Wibowo D. (2024) The Relationship between Pont, Bolton Analysis, DMF Index and the Severity of Malocclusion at SDN Gambut 10, Banjar Regency, South Kalimantan, Indonesia, Cumhuriyet Dental Journal, 27(2):92-97.

Background

Malocclusion is abnormal relationship between upper and lower jaw.[1] Malocclusion can lead to not only facial aesthetics dissatisfaction, difficulty in speaking, chewing and swallowing, but also temporomandibular joint disorder and orofacial pain.[2] Malocclusion and its impact to oral function and facial aesthetics have become significant points in the field of oral health. According to World Health Organization (WHO), malocclusion is the third biggest problem in oral health, after periodontal disease and dental caries.[2] Based on Indonesia's National Basic Health Research in 2018, the prevalence of oral health problem in Indonesia was 57.6%, while in South Kalimantan province was 60%. The prevalence of malocclusion in elementary school students was 15,6%.[4] There were still no data regarding malocclusion South Kalimantan Province. SDN Gambut 10 is one of the elementary schools in Banjar Regency, South Kalimantan province. Based on previous study, it was known that 9 out of 10 students at SDN Gambut 10 grade 3 suffered from malocclusion. However, its etiology was still unknown.

Orthodontic diagnosis and treatment planning can be aided by using study model. As the 3-dimensional jaw printing, various measurements can be done on the study model.[5] Arch width in each jaw (maxilla and mandible) can be analyzed using Pont's and Bolton's analysis. Besides, arch length discrepancy also plays an important role in determining orthodontic treatment plan. These methods are very useful for dentists and orthodontists to determine the etiology of malocclusion, which relates to orthodontic treatment plans, including the decision to perform tooth *slicing*, expansion, extraction, or combination of those to obtain good occlusion.[6] However, the normal values used in those analyses were made for the Caucasian ethnic group, as the original researches were done on Caucasians. Caucasians tend to have narrower jaws and more pointed noses compared to other ethnic groups.[7] On the other hand, Mongoloid ethnic group dominates most of Indonesia. As one of the 38 provinces in Indonesia, South Kalimantan was dominated by Banjar sub-ethnic group.[8-10] South Kalimantan region mostly consists of wetland areas, whose civilians may have special malocclusion

characteristics. There was still no data available on the characteristics of malocclusion in this sub-ethnic group.

Based on the explanation above, research regarding the severity of malocclusion cases and their etiology in students in 4th to 6th grade at SDN Gambut 10, Banjar Regency, South Kalimantan was performed. There has been no previous research regarding the etiology of malocclusion in wetland communities, including SDN Gambut 10.

Materials and Methods

Approval was received for this study from the local ethical review committee (reference number: 048/KEPKG-FKGULM/EC/III/2023, approved on March, 23rd 2023). This was a cross-sectional observation research to analyze the severity of malocclusion and its possible etiology. Total sampling was done on students at SDN Gambut 10, Banjar Regency, South Kalimantan with the inclusion criteria: age 9-12 years old (grade 4-6), residing in South Kalimantan, and willing to participate in this research. The exclusion criteria were samples that could not be taken impression or the impression could not be analyzed.

There were 104 students in grade 4-6 in SDN Gambut 10. Alginate impression was taken on all 104 samples, then poured with type III dental plaster to create study models. Several measurements were made on the models: premolar and molar width (Pont's analysis), tooth size discrepancy (Bolton's analysis), and arch length discrepancy. The severity of malocclusion was determined based on ICON index, while the severity of caries was categorized using DMF index. The data obtained were displayed in the form distribution and percentage based on sex, then Chi-square test was performed to analyze the relationship between the variables.

Pont's Analysis

The result of Pont's analysis can be used to determine whether dental arch expansion in the premolar and molar region needs be done during orthodontic treatment. The following parameters are required to calculate the index:[11]

- The sum of the mesiodistal width of 4 maxillary incisors (SI)
- The measured premolar value (PPV) is obtained by measuring the inter-premolar width from the distal pit of the maxillary first premolar on both sides
- The measured molar value (MMV) is obtained by measuring the inter-molar width, which is measured from the mesial pit of the maxillary first permanent molar on both sides.
- The calculated premolar value is obtained using the formula: (SI/80) x 100
- The calculated molar value is obtained using the formula: (SI/64) x 100

Bolton's Analysis

Bolton's analysis is widely used to determine the discrepancy between the size of maxillary and mandibular teeth. The mesiodistal width of 12 maxillary teeth from the incisor to the first permanent molar on either side is measured (Figure 1). Then, the sum of the mesiodistal width of 12 mandibular teeth is measured. The overall ratio is calculated using the formula (the sum of 12 mandibular teeth divided by the sum of 12 maxillary teeth) times 100. Similarly, the anterior ratio is calculated using the formula (the sum of 6 mandibular anterior teeth divided by the sum of 6 maxillary anterior teeth) times 100. The normal values of the overall and anterior Bolton ratios were determined to be 91.3% and 77.2%, respectively. The overall ratio greater than 91.3% suggests that the mandibular teeth material is in excess, while an overall ratio of less than 91.3% suggests the mandibular teeth material is deficient in comparison to those in maxillary. The anterior analysis follows the same principle.[12]

Arch Length Discrepancy (ALD)

ALD may manifest itself as crowding or spacing in dental arches. Arch length discrepancy is the difference between the available space minus the required space, where the available space represents the basal region available in the dental arch (Figure 2), and the required space is the sum of the mesiodistal length of existing teeth.[13]

ICON Index

Occlusal trait scores include:

1. Upper and lower segment alignment
2. Anterior vertical relationship, centerline, impacted teeth, upper and lower buccal

segment alignment, buccal segment AP relationship, buccal segment vertical

relationship, crossbite, missing teeth

3. Esthetic assessment based on IOTN esthetic component, overjet, reverse overjet,

upper and lower incisor inclination relative to occlusal plane, upper arch crowding/

spacing, lip competenc

ICON index measures several points, which include:[14]

1. Upper and lower segment alignment
2. Anterior vertical relationship, centerline, impacted teeth, upper and lower buccal segment alignment, buccal segment antero-posterior relationship, buccal segment vertical relationship, crossbite, missing teeth
3. Esthetic assessment based on IOTN esthetic component, which visually scores: overjet, reverse overjet, upper and lower incisor inclination relative to occlusal plane, and upper arch crowding/spacing.

DMF Index

This index determines the number of decayed (D), missing (M) and filled (F) teeth on dental surfaces. The sum of those tooth surfaces was divided by the total number of evaluated surfaces (molars and premolars having five surfaces and incisors and canines having four surfaces).[15]

Figure 1: Measuring the mesiodistal width of the second right premolar using caliper.[13]

Figure 2: Measuring available space with brass wire.[13]

Results

The most common type of malocclusion found was Angle class I malocclusion (92%), followed by Angle class II (4%) and class III (4%), with anterior crowding. Anterior crowding was marked with a negative value of space discrepancy on each maxilla and mandible. Space discrepancy is the contrast between mesiodistal teeth size and the length of the alveolar base on each jaw. Descriptive data of each arch length and space discrepancy are shown in Table 1.

Based on Pont's analysis, there were arch constrictions both in premolar and molar regions in all samples. Mild premolar arch constriction occurred the most (69.2%), followed by moderate (26.9%) and severe constriction (3.8%). In the molar region, mild constriction was found at 61.5%, while moderate constriction was 23.1% and severe constriction was 15.4%. Based on Bolton's analysis, it was known that there was nonconformity of teeth size in the mandible (on anterior teeth in 76.9% of samples, and overall teeth in 65.4% of samples) (Table 2).

The severity level of malocclusion based on ICON index showed that most malocclusion cases were categorized as easy (42.3%), followed by moderate (23%), difficult (18.5%), and extremely difficult (11.5%) (Table 3). There was no significant difference in the ICON score between men and women samples ($p<0.05$). Based on DMF category results, it was shown that most samples had very low and low carious teeth (Table 4).

Kolmogorov-Smirnov test and Levene's homogeneity test showed that all data above were normal and homogeneous. Based on independent T-test results, there was no significant difference in all variables between men and women, except in the maxillary arch length. The mean of maxillary arch length in male samples was significantly higher than that in female samples ($p<0.05$). However,

there were no significant difference in mandibular arch length and space discrepancies.

There was a correlation between maxillary molar arch constriction, mandibular space discrepancy and the severity of malocclusion, although there was no significant correlation between the severity of malocclusion and other etiological variables of malocclusion in this study (Table 5).

Table 1. Mean of arch length and space discrepancies based on gender.

Gender	Maxillary arch length (mm)	Mandibular arch length (mm)	Maxillary space discrepancy (mm)	Mandibular space discrepancy (mm)
Men	102.69 ± 5.60	92.92 ± 4.52	-1.53 ± 6.36	-0.84 ± 1.48
Women	97.08 ± 5.99	89.65 ± 4.04	-1.81 ± 3.92	-2.38 ± 0.90

Table 2. Mean of Pont's and Bolton's analysis variables.

	Pont's Analysis		Bolton's Analysis			
Gender	Maxillary premolar length (mm)	Maxillary molar length (mm)	6 maxillary anterior teeth (mm)	6 mandibular anterior teeth (mm)	12 maxillary teeth (mm)	12 mandibular teeth (mm)
Men	38.88 ± 2.42	47.35 ± 3.40	49.65 ± 4.17	39.35 ± 3.44	104.23±7.63	94.12 ± 4.51
Women	38.19 ± 4.66	47.27 ± 6.31	46.92 ± 4.15	39.50 ± 2.72	98.88 ± 3.43	92.04 ± 5.04

Table 3. ICON category result

	Easy (score 0-29)	Mild (score 30-49)	Moderate (score 50-62)	Difficult (score 63-76)	Very difficult (score >77)
Men	12 (11.5%)	4 (3.8%)	12 (11.5%)	12 (11.5%)	12 (11.5%)
Women	32 (30.8%)	0 (0%)	12 (11.5%)	8 (7.6%)	0 (0%)
Total	**44 (42.3%)**	**4 (3.8%)**	**24 (23%)**	**20 (18,5%)**	**12 (11.5%)**

Table 4. DMF category result

	Very low (score <3)	Low (score 4-6)	Moderate (score 7-9)	High (score >10)
Men	35 (33.7%)	0 (0%)	0 (0%)	7 (6.7%)
Women	28 (27.9%)	21 (20.2%)	14 (13.5%)	0 (0%)
Total	**63 (60.6%)**	**21 (20.2%)**	**14 (13.5%)**	**7 (6.7%)**

Table 5. P values of correlation between etiology of malocclusion with Malocclusion Severity Level (ICON)

	Pont premolar analysis	Pont molar analysis	Anterior Bolton analysis	Overall Bolton analysis	Maxillary space discrepancy	Mandibular space discrepancy	DMF
ICON	0.317	0.026*	0.262	0.139	0.107	0.005*	0.392

Note: * significant

Discussion

This research was done on grade 4-6 elementary school students (age range 9-12 years old) because the second phase of mixed dentition happens in this age range. In addition, growth spurt, which is the peak acceleration of skeletal growth and development, occurs in the age range in boys and girls.[16] The prevalence of dental patients with the age of 9-12 years old are also quite high, and they are expected to be able to cooperate well and follow dental procedures, including undergoing dental impressions.[17-19] As early malocclusion had been detected and its possible etiological factors had been known, it is better to have earlier intervention treatment to prevent it become worse.[18]

There was no significant difference in the severity of malocclusion between male and female samples. The same result was also found on other variables, such as arch width and length, teeth size, as well as the severity of caries. This result was in line with Farani's research (2021), which reported that gender does not influence the occurrence of malocclusion because men and women have the same possibility of malocclusion.[20-21] Malocclusion can be caused by differences in the size of the teeth and jaw arches, which are more related to genetic factors than to gender.[21] However, the results of this study contradict other studies which stated that men tend to have a higher severity level of malocclusion than girls do.[21]

In this research, the observed etiological factors were: arch length and width, teeth size and caries severity level. There was a correlation between arch constriction in the maxillary molar area, mandibular space discrepancy and the severity level of malocclusion. Upper molar arch constriction may be caused by various things, for example: caries proximal, habitual mouth breathing, finger biting, mastication muscle imbalance, and genetic factors. Space discrepancy that was found in this research was in the form of a lack of arch length compared to teeth size. This can also be caused by proximal caries, premature loss of teeth, and genetic factors. The majority of samples had tooth displacement to the mesial, which would also cause the shortening of arch length. The presence of proximal caries, as well as missing teeth, may cause mesial tooth migration which will result in the reduction of arch length and tooth spacing.[22-24] Moreover, premature primary tooth loss may lead to the loss of permanent tooth

eruption reference, which will further cause arch shortening and the worsening of malocclusion.[25]

It was found that there was no significant correlation between the severity level of malocclusion (based on ICON index) and observed etiological factors. It was due to the etiology of malocclusion was very complex. Kusnoto (2014) explained that there were several factors that lead to malocclusion, which were categorized into general and local factors. General factors include congenital, hereditary, environmental, malnutrition, and bad habits, while local factors are anomalies in the number of teeth, tooth shape, tooth size, caries and premature extraction of deciduous teeth.[26] Other research also stated that the longer the duration and the frequency of bad habits, the worse the severity of malocclusion.[27]

Dental caries can cause the shortening of arch length,[22] as interproximal caries can reduce mesiodistal tooth size and cause the adjacent tooth to migrate to the mesial. It can result in crowded teeth as well as abnormal molar relations.[28] Severe caries in primary molars will also cause the disintegration of tooth crowns and may alter the chewing habit in children over time. As a result, temporomandibular joint disorder may occur, which may lead to the worsening of malocclusion.[22] However, no correlation was found between the severity of caries and the severity of malocclusion in this study. This result was in line with research by Fadel (2022) and Luzzi (2011).[29-30] On the other hand, research by Zhou (2016) agreed that there was a significant correlation between the severity of caries and the incidence of malocclusion in younger-age children.[22] Research by Singh (2011) also stated the same opinion while using the other malocclusion severity index, namely the *Dental Aesthetic Index*.[31] The reason why the results in this study were not significant was because the majority of respondents had very low and moderate caries. Besides, the dental caries index used in this study (DMF) did not measure interproximal caries in particular.[32]

The exact etiology of malocclusion that has the strongest correlation with the level of malocclusion severity is still not found yet. Further studies need to be carried out on the other possible etiological factors, such as: genetics, the presence of bad habits as well the history of local factors (tooth persistence or premature loss). The findings about the constriction of the jaw arch in the molar area may also implicate that Pont's analysis may not apply to the Banjar tribe aged 9-12 years old. Additionally, time delays in pouring casting with dental plaster during the study model procedure may also cause measurement errors. To overcome this matter, it is suggested to use an intraoral scanner to obtain more precise measurement results and more comfortable for samples. However, measurement using the intraoral scanner was not done in this study as it was still unavailable in our area and it cost a lot to provide it.

Conclusions

The characteristics of malocclusion in grade 4-6 students at SDN Gambut 10 are mild level of malocclusion with constriction of both the upper and lower jaw. There is a correlation between constriction in the molar region and lower jaw crowding with the severity of malocclusion. Malocclusion occurs due to various etiological factors, thus its severity cannot be determined by some factors alone

Acknowledgements

This research was funded by Universitas Lambung Mangkurat lecturer research grant no. 615/UN8/PG/2023.

Conflict of Interest Statement

The authors declare no conflict of interest.

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Cumhuriyet Dental Journal, 27(2): 98-103, 2024
DOI: https://doi.org/10.7126/cumudj.1410330

Cumhuriyet Dental Journal

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

Color Adjustment Potential of Two Single Shade Resin-Based Composites Before and After Staining

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Research Article

History

Received: 26/12/2023
Accepted: 08/03/2024

ABSTRACT

Objective: This in vitro study aims to evaluate the visual color adjustment potential (CAP-V) of two single shade resin-based composite before and after coffee staining.

Materials and Methods: Class 3 cavities were prepared on the mesiobuccal surfaces of a total of 60 acrylic maxillary central denture, 30 in A2 shade and 30 in B1 shade. For the restoration of cavities, two different single-shade resin based composites (Omnichroma and Charisma Diamond One) and a nanohybrid composite (Filtek Ultimate, A2 and B1 Body shades) were used. After the restoration process, the samples were polished. The visual color adjustment potential (CAP-V) of all samples was evaluated 3 times respectively: before the staining process, after the staining process and after the re-polishing process. Data were analyzed with One-way analysis of variance (ANOVA) and Tukey tests (p=0.05).

Results: The Omnichroma B1 groups showed better CAP-V values for initial and re-polished groups. In the groups after staining, the best CAP-V values were in the Charisma Diamond One A2 group and the worst values were in the Filtek B1 group (p<0.001). Additionally, no statistically significant difference was found between Omnichroma and Charisma Diamond One in any group except the re-polished B1 group.

Conclusions: Within the limitation of this study, we can conclude that B1 shade dentures restored with single-color resin composites are more likely to lose visual harmony due to discoloration over time, compared to A2 shade dentures. However, it was seen that the visual harmony problem caused by staining could be reduced by re-polishing. The single-shade resin composites used in this study generally have similar CAP-V values.

Keywords: Color Adjustment Potential, Color Stability, Resin Composite, Staining

İki farklı tek renkli rezin kompozitin renklendirme öncesi ve sonrası renk uyum potansiyellerinin değerlendirilmesi

Süreç

Geliş: 26/12/2023
Kabul: 08/03/2024

ÖZ

Amaç: Bu in vitro çalışma, iki farklı tek renkli rezin kompozitin kahve ile renklendirme öncesi ve sonrası görsel renk uyum potansiyelini (CAP-V) değerlendirmeyi amaçlamaktadır.

Gereç ve Yöntemler: 30 adet A2 renk tonunda 30 adet de B1 tonunda olmak üzere toplam 60 adet akrilik santral dişin meziobukkal yüzeylerine sınıf 3 kaviteler açıldı. Kavitelerin restorasyonu için 2 farklı tek renkli rezin kompozit (Omnichroma and Charisma Diamond One) ve kontrol grubu olarak da farklı renklere sahip bir nanohibrit kompozit (Filtek Ulitimate) kullanıldı. Restore edilen dişler kahve ile renklendirme işlemine tabi tutuldu ve renklendirme sonrasında polisaj işlemi uygulandı. Tüm örneklerin renklendirme işleminden önce, renklendirme işleminden sonra ve polisaj işleminden sonra olmak üzere toplam 3 kez görsel renk uyum potansiyelleri değerlendirilmiştir. Veriler tek yönlü varyans analizi (ANOVA) ve Tukey testleri ile analiz edildi (p=0,05).

Bulgular: Omnichroma B1 grupları, başlangıç ve yeniden polisajlanmış gruplar içinde daha iyi CAP-V değerleri gösterdi. Renklendirme sonrası gruplar arasında en iyi CAP-V değerleri Charisma Diamond One A2 grubunda, en kötü değerler ise Filtek B1 grubunda görüldü (p<0,001). Ayrıca Omnichroma ve Charisma Diamond One arasında yeniden cilalanan B1 grubu dışında hiçbir grupta istatistiksel olarak anlamlı bir fark bulunamadı.

Sonuçlar: Bu çalışmanın sınırları dahilinde, tek renkli rezin kompozitlerle restore edilen B1 renk akrilik dişlerin, A2 renk akrilik dişlere göre zamanla renk değişikliği nedeniyle görsel uyumunu kaybetme olasılığının daha yüksek olduğu sonucuna varıldı. Ancak renklenmeden kaynaklanan görsel uyum sorununun yeniden cilalama yapılarak azaltılabileceği gözlendi. Bu çalışmada kullanılan tek renkli rezin kompozitler genel olarak benzer CAP-V değerlerine sahiptir.

Anahtar Kelimeler: Renk uyum potansiyeli, renk uyumu, rezin kompozit, renklenme

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How to Cite: Karadağ G, Haberal M, İren AY, Bayraktar Y. (2024) Color Adjustment Potential of Two Single Shade Resin-Based Composites Before and After Staining, Cumhuriyet Dental Journal, 27(2):98-103.

Introduction

Resin based composites (RBC) are widely used in restorative dentistry due to the demand for aesthetic procedures and the advocacy of minimal removal of dental tissues during tooth preparation.[1] For a composite restoration to be effective, the natural tooth tissue and the RBC must have such a harmonious hue that the human eye cannot tell them apart. The choice of RBC in restorative operations is based on color appearance, namely color match, color stability, and color interactions.[2] Color selection in resin composite restorations can be difficult because it varies depending on environmental and dentist-dependent variables.[3]

Recently introduced single-shade RBC match almost all color shades. However, this is also related to the size of the restoration and the tooth tissues surrounding it. Due to these properties, also called the chameleon effect, these composites simplify the restorative procedure by eliminating the color selection step.[4,5] Single-shade RBC have an added benefit known as the Color Adjustment Potential (CAP), which describes how perceptual and physical components interact.[6]

The interaction between two components, CAP-V (visual) and CAP-I (instrumental), is measured and described using the term Color Adjustment Potential (CAP). The perceptual component of a material is represented by CAP-V, which is computed based on the ratings that observers assign to the materials' color adjustment. Furthermore, the material's physical qualities are represented by CAP-I, which is computed using color difference values acquired using a color measurement tool.[7]

Staining is still seen as a significant disadvantage affecting the success of aesthetic restorations.[8] Composite resin staining may be due to intrinsic or extrinsic factors. Changes in the color of the resin material that are brought about by modifications to the resin matrix, the resin/filler interface, or chemical changes arising from the oxidation or modification of the amine catalyst, the polymeric matrix structure, or the unreacted methacrylate groups are referred to as intrinsic color changes.[9,10] On the other hand, extrinsic factors originate from superficial or deep absorption of colorants due to exposure to external sources leading to stains.[10,11]

This in vitro study aims to evaluate the CAP-V of a multi-shade nanofill composite (Filtek Ultimate) and two different SSRBC (Omnichroma and Charisma Diamond One) on class 3 restorations of acrylic denture in 2 different shades, both before and after staining with coffee.

The null hypothesis is as follows:

1. There is no difference between the CAP-V values of the RBC investigated in this study.

2. The color adjustment potentials of the RBC investigated in this study are similar after staining and re-polishing.

Materials and Methods

Preparation and distribution of samples

In this study, acrylic maxillary right and left central incisor dentures (Denture Lux Pe, Ankara, Turkey) in A2 and B1 shades according to the VITA Classic scale were used.

Class 3 cavities were prepared on the mesial surfaces of 60 dentures, 30 of which were A2 and 30 were B1 shades. The dimensions of the cavities were adjusted to be 2 mm mesiodistally and 3 mm inciso-gingivally. The palatinal wall of the prepared samples was 1 mm (Figure 1). Cavity preparations were performed by a single operator under water cooling, using round drills (#801-014, Hicare Medical Co. Ltd, Guangzhou, China), and after the preparation, the margins were minimally beveled with a 45° angle.

The prepared samples were randomly divided into 3 groups for each shade (n=10).

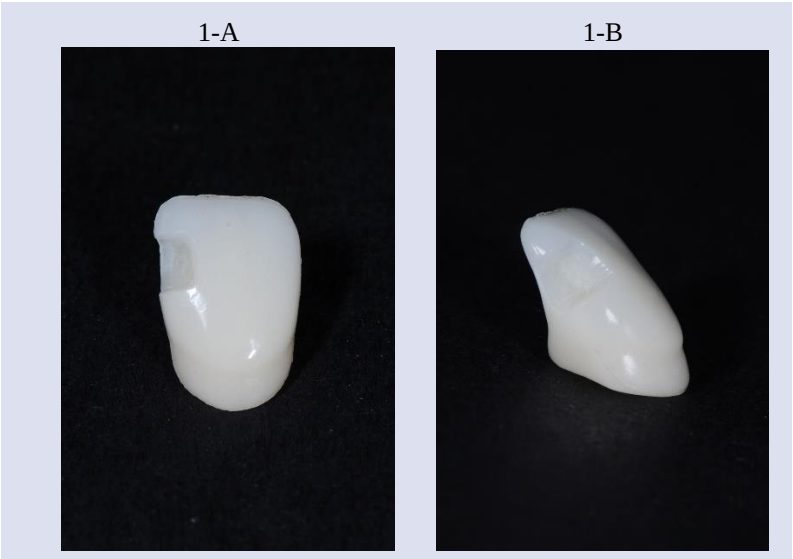

Figure 1: A representative sample of prepared cavities

Restoration

For restoration of cavities, two different single-shade universal RBC (Omnichroma and Charisma Diamond One) and one multi-shade universal nanocomposite (Filtek Ultimate; B1 Body and A2 Body shades), which we preferred as the control group, were used (Table 1). efore the restorations, a universal adhesive agent (Scotchbond Universal, 3M/ESPE, St. Paul, MN, USA) was applied according to the manufacturer's instructions and polymerized with a LED curing unit (Elipar, 3M ESPE, St. Paul, MN, USA) with 1,200 mW/cm^2 irradiation for 10 seconds. Restorations were standardized with a clear silicone stamp. After the bonding process, the composites were placed to the cavities, stamped with a slight pressure force, and polymerized for 20 seconds. The final finishing and polishing procedures were performed using Soflex discs respectively (3M ESPE, St. Paul, MN, USA). Course discs were not used. The discs were replaced with every three restorations. For 24 hours, the dentures were stored at room temperature in distilled water.

CAP-V rating

Eight dentists (four females and four male), who were tested and found successful according to ISO TR28642, were selected as observers. Every sample was visually assessed by observers in a light booth using a 0°/45° viewing geometry at 1-minute intervals while the samples were illuminated by a D65 light source and were situated at a distance of around 25 cm. Color match between the tooth and the restoration was scored from 0 to 4. According to this scale used in previous studies; "0" means excellent match, "1" means very good match, "2" means not a very good match (border zone incompatibility), "3" means obvious incompatibility and "4" means major (pronounced) discord.[5,7]

After the initial color match evaluation, the samples were kept in coffee solution (Nescafe Classic, Nestle Suisse, Vevey, Switzerland) at room temperature for 48 hours. After the staining process, the samples removed from the coffee solution were washed with tap water, and then the color match was evaluated for the second time. Then, all restorations were re-polished and color adjustment potential was evaluated for the third time. The stained and then re-polished samples created subgroups for each shade and restorations. Thus, we obtained 18 groups. The groups in this study and their abbreviations were shown in Table 2. Tukey tests and One-way analysis of variance (ANOVA) were used to analyze the data. (p=0.05).

Results

When the initial CAP-V of the restorations were examined, the best color adjustment was observed in OB, while the lowest color adjustment was observed in CA (p= 0.001). When the CAP-V of the restorations after being stained in coffee solution for 48 hours was examined, the best color adjustment was observed in SOA, while the lowest color adjustment was observed in SFB (p<0.001). When the CAP-V of the restorations re-polished after staining was examined, the best color adjustment was observed in POB, while the lowest color adjustment was observed in PCB (p< 0.05). The mean CAP-V scores of the groups at initial, after staining and after re-polishing are given in Table 3.

When the CAP-V values of the restorations after initial, staining and re-polishing were examined, there was no statistically significant difference between the Filtek Ultimate and Omnichroma groups in A2 shade dentures (p< 0.05). Statistically significant differences were found between the initial, post-staining and post-re-polishing CAP-V values of the other groups (p<0.05).

The initial CAP-V values of the restorations made with all three composites on B1 shade dentures were statistically significantly better than the CAP-V values after staining. However, no significant difference was observed between the initial CAP-V values and re-polished after staining CAP-V values on B1 shade dentures.

Omnichroma showed better CAP-V scores than Charisma Diamond One in all groups. However, this difference was statistically significant only in the repolished after staining group on B1 shade dentures.

The mean CAP-V values of the groups were shown in Table 3.

Table 1: Composition of used resin composites.

Material	Type	Content
Omnichroma (Tokuyama Dental, Tokyo, Japon)	Supra-nano filled	Organic: Urethane dimethacrylate, Triethylene glycol dimethacrylate, Mequinol, Dibutyl hydroxyl toluene and UV absorber Inorganic: Spherical silica-zirconia filler. 79 wt%, 68 vol%
Charisma Diamond One (Kulzer Gmbh, Hanau, Germany)	Nanohybrid	Organic: Urethane dimethacrylate, Bis-methacryloxyethoxy phenyl propane, Bisphenol-A ethoxylated dimethacrylate, Bisphenol-A glycidyl dimethacrylate, Triethylene glycol dimethacrylate Inorganic: Pre-polymerized fillers (17 µm): Strontium glass (400 nm), lanthanide fluoride (100 nm), Fumed silica (16 nm), FAISi glass (850 nm) 81 wt%, 65 vol%
Filtek Ultimate Body (3M/ESPE, St. Paul, MN, USA)	Nanofill	Organic: Bisphenola-A glycidyl dimethacrylate, Urethane dimethacrylate, Ethylene glycol dimethacrylate, Polyethylene glycol dimethacrylate, Bisphenol-A ethoxylated dimethacrylate, Triethylene glycol dimethacrylate Inorganic: Non-agglomerated/non-aggregated 20 nm silica filler, Non-agglomerated/non-aggregated 4 to 11 nm zirconia filler, Aggregated zirconia/silica cluster filler wt%, 63.3 vol%

Table 2: The groups in this study (abb: abbreviations)

Denture Shade	Restorative Resin Composite	Initial groups abb.	Stained groups abb.	Re-polished groups abb. (after staining)
A2	Filtek Ultimate A2 Body	FA	SFA	PFA
A2	Omnichroma	OA	SOA	POA
A2	Charisma Diamond One	CA	SCA	PCA
B1	Filtek Ultimate B1 Body	FB	SFB	PFB
B1	Omnichroma	OB	SOB	POB
B1	Charisma Diamond One	CB	SCB	PCB

Table 3: Mean CAP-V scores of the groups at initial, after staining and after re-polishing.

Group	Mean CAP-V	Group	Mean CAP-V	Group	Mean CAP-V	
FA	1.76 ± 0.76^{Abc}	SFA	2.28 ± 0.64^{Abc}	PFA	1.68 ± 0.54^{Ab}	p>0.05
OA	1.41 ± 0.76^{Aabc}	SOA	1.24 ± 0.46^{Aa}	POA	1.03 ± 0.50^{Aab}	p>0.05
CA	2.09 ± 0.69^{Ac}	SCA	1.38 ± 0.56^{Ba}	PCA	1.13 ± 0.53^{Bab}	P<0.05
FB	1.04 ± 0.71^{Aab}	SFB	2.66 ± 0.46^{Bc}	PFB	1.48 ± 0.63^{Ab}	P<0.05
OB	0.76 ± 0.67^{Aa}	SOB	$1.66\ \ 0.71^{Bab}$	POB	0.69 ± 0.52^{Aa}	P<0.05
CB	$1.28 \pm 0,67^{Aabc}$	SCB	2.19 ± 0.65^{Bbc}	PCB	1.74 ± 0.61^{ABb}	P<0.05
	p<0.05		p<0.05		p<0.05	

*The same lowercase letters mean there is no statistically significant difference between the groups in up to down direction. The same uppercase letters means that there is no significant difference between the groups in same line.

Discussion

It is crucial that the color of the restorative material employed is invisibly consistent with the tooth's color to provide a solution that can live up to the ever-higher aesthetic standards of today. Some of the primary disadvantages of resin composites include their limited coverage of the human tooth color spectrum, lack of color stability, and uneven color definition of different materials.[2] The manufacturing of resin composite color systems has recently focused on color harmony, with less emphasis on the color pigments added to the content and more on the sophisticated photonic nanostructure of filler particles and how they are arranged inside the composite structure. This project reduced the number of colors by introducing composite materials with altered optical characteristics, which in turn produced the phenomena known as structural color. The production of composite systems with fewer colors has begun, and these systems are still developing.[12] The filler content and size of the composite, the organic matrix's composition, the tooth's size and structure, the composite layering technique, and the color and brand of the composite itself are just a few of the numerous sub-factors that can affect color adjustment in composite resin restorations.[13,14] A visual measurement technique was used to assess the color adjustment potential of the composites before and after coffee staining and re-polishing. Different denture colors (B1 and A2), single-shade RBC (Omnichroma, Charisma Diamond One), and multi-shade universal nanocomposite (Filtek Ultimate; B1 Body and A2 Body shades) were used in this study. Due to the evaluations performed in this study, the first hypothesis was rejected because there were differences between CAP-V values in restorations made with different RBC. The color adjustment potentials of the RBC examined in this study after staining and re-polishing were partially rejected because they were similar in some groups and not in others.

Natural teeth have several layers and colors. Moreover, the color of natural human teeth is the result of complex interactions between light and teeth, which are influenced by various factors such as tooth type, location and age.[15] In this study, for color and size standardization of teeth and cavities, instead of extracted teeth, acrylic dentures consisting of a layered structure and selected from the common colors of natural teeth (B1 and A2) were preferred in accordance with the dental literature.[16,17]

The CAP values of composite resins are assessed both visually and instrumentally in several types of investigations.[5-7] An objective technique for measuring hue, chroma and lightness differences in color is called instrumental assessment.[18] The use of visual methods to evaluate color harmony or disharmony is often subjective, but it can be a determining factor in the overall acceptance of treatment by the patient.[7,19] In our study, we used the CAP-V assessment to measure color harmony.

In the literature, visual color assessments were performed at an observation angle of 0°/45°, light, and observer-sample distances of roughly 25-30 cm. Furthermore, a neutral grey background and a D65 light source were employed in other investigations. In this study, in accordance with current research, a scoring system was used, where 0 points corresponds to color incompatibility and 4 points corresponds to perfect harmony. The visual analysis method used in our study is similar to the methods used in the dental literature.[7,16,20]

In our study, Omnichroma without Bis-GMA exhibited a higher color adjustment potential than Filtek Ultimate Body and Charisma Diamond One resin composites containing Bis-GMA. Durand *et al.*[21] concluded in their study on composite disc samples that Omnichroma has the highest color adjustment and translucency adjustment potential among the resin composites tested (Filtek Universal, Harmonize, and Omnichroma), despite

the fact that this is at conflict with a study reporting a positive correlation between the amount of Bis-GMA in resin composite samples and the translucency of the composite material.[22] This is consistent with our research, which demonstrates that Omnichroma's translucency is much enhanced in situ, enabling it to primarily reflect the color of the environment and producing better color correction.

In the study by Zajkani *et al.*[9] the samples immersed in coffee and tea solutions did not return to their initial color values even after re-polishing, but improved significantly, in agreement with the results of previous studies. Re-polishing will not bring back the original color of the discoloration because internal discoloration results from coloring ingredients penetrating the organic phase and causing surface discoloration.[23]

In comparison to other composite types (nanofilament, nanohybrid, and microhybrid), resin composites with supra-nano spherical filler particles display better scattering and light transmission. The size and form of the filler particles are most likely to blame for this.[24] Based on CAP-I data, the supra-nano spherical Omnichroma resin composite in our investigation showed better color adjustment potential than the nanohybrid resin composite Filtek Ultimate Body and Charisma Diamond One groups. In our study, Omnichroma provided the best color adjustment potential in shade B1. Iyer *et al.*[17] compared the color adjustment potential of three different composites (Omnichroma, Tetric Evo Ceram and TPH Spectra ST) in different shades (A2, B1, B2, C2, D3). Similar to our study, theirs stressed that lighter teeth had a greater Omnichroma color adjustment than darker teeth. Chen *et al.*[25] compared the color matching of newly developed composites containing supra-nano filler particles (Omnichroma and Estelite Sigma Quick) with other composite types. They argued that these materials exhibited better color matching in A2, A3 and A4 shade teeth compared to A1 shade teeth. In a study comparing the color matching of Omnichroma material with multicolored RBC on central dentures of different shades (A1, A2 and A3), it was reported that there was no significant difference between dentures shades.[16]

Shade A is a reddish brown hue while shade B is a yellow-red color according to the Vita Shade Guide.[26] Shade B has more lightness than shade A does. In comparison to the backdrop, lighter hues more clearly display the effect of color shift.[27] According to our findings, B1 colored dentures were more likely than A2 colored dentures to gradually lose their visual harmony because of discoloration. In their study, Manabe *et al.*[28] also discovered that the discoloration of the B1 shade of composite resin was greater in coffee and tea than in A1.

This study was carried out in an in vitro environment and acrylic dentures were used in the study. The color adjustment potential of the samples was evaluated only visually and was not compared with any other evaluation method. Furthermore, color adjustment potentials were investigated for two different shades and in one type of cavity type and one type of composite finishing procedure. The specimens were stained with a single beverage and the effect of ageing on long-term color stability was not evaluated. These can be considered as limitations of the study.

Conclusions

Within the limitations of this study, we can conclude that B1 shade dentures restored with single-shade RBC are more likely to lose visual harmony due to discoloration over time, compared to A2 shade dentures. However, it was seen that this visual harmony problem caused by staining could be reduced by re-polishing. Therefore, we can comment that these two resin composites have similar CAP-V values. Coloring of composite resins has a negative effect on CAP-V values, while re-polishing has a positive effect on CAP-V values.

Acknowledgements

We would like to thank the dentists who performed the CAP-V evaluation of the samples in our study.

Conflicts of Interest Statement

The authors declared that there is no conflict of interest.

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Cumhuriyet Dental Journal, 27(2): 104-108, 2024
DOI: https://doi.org/10.7126/cumudj.1411544

Cumhuriyet Dental Journal

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

Prevalence of Third Molar Agenesis in the Turkish Subpopulation

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Research Article

History

Received: 28/12/2023
Accepted: 21/04/2024

ABSTRACT

Purpose: The aim of this study is to investigate the prevalence and distribution of third molar (3M) agenesis in the Turkish subpopulation in a wide age range.

Material and Methods: Clinical examination and radiographic evaluations were performed in a total of 1479 patients (905 females, 574 males) aged between 15 and 83 years. Gender and age information of the patients, presence/absence of 3M agenesis, number of agenesis, jaw localization (maxilla/mandible) and relevant tooth number were noted. Data were analyzed using chi-square test ($p<0.05$).

Results: The prevalence of one or more third molar agenesis was determined 25.3% (374 individuals). The prevalence of third molar agenesis was higher in females than in males, but there was no significant difference between the genders ($p=0.380$). The group with at least 3M deficiency was between the ages of 15-22 with a prevalence rate of 22.1%. Agenesis was most common in the right maxillary 3M (18) (16.7%). All third molars were missing in 4.9% of the patients.

Conclusions: In the Turkish subpopulation, the different prevalence rates of third molar agenesis in various age groups, especially the low rates in the new generation, may provide important clues in the investigation of genetic variations and adaptations as well as third molar extraction protocols. It would be useful to conduct new, more comprehensive studies on this subject.

Keywords: Agenesis, Prevalence, Third Molar.

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How to Cite: Çelik B. (2024) Prevalence of Third Molar Agenesis in the Turkish Subpopulation, Cumhuriyet Dental Journal, 27(2):104-108.

Introduction

Dental agenesis is the congenital absence of one or more primary or permanent teeth. It also refers to a tooth that has not erupted in the oral cavity and is not visible on radiographs.[1] Today, most people have problems with agenesis or eruption position of their third molar (3M) teeth.[2] Compared to other teeth in the dental arch, agenesis is thirteen times more common in 3M teeth.[3]

Factors such as systemic diseases, environmental and genetic factors, dietary habits and chewing function play a role in the etiology of tooth agenesis.[1] It is also argued that lack of space in the jaw is an important factor.[4] Since 3M teeth are the last teeth to develop and erupt in the dental arch, they are considered to be the most sensitive teeth to environmental factors.[5]

Although agenesis does not directly cause pathology, it can be the cause of developmental problems, especially in the maxillofacial region.[6] For this reason, the morphological, demographic and developmental determinants of M3 agenesis are a frequently researched topic among dentists.[7]

The incidence of 3M agenesis also varies between geographical regions.[7] In general, most researchers have focused on certain age groups in assessing the prevalence of agenesis.[1,6,8-11] There are a limited number of studies including different age groups.[4,12,14] The aim of this study was to investigate the prevalence and distribution of 3M agenesis in age groups of different generations in a group of Turkish patient population.

Materials and Methods

The approval was received from Ankara Yıldırım Beyazıt University Ethics Committee for the study, which was planned as a randomized cross-sectional study, in accordance with the Declaration of Helsinki (ID: 2022-1117). Between 11.2022 and 03.2023, 1479 patients, male and female of Turkish origin, aged 15 and over, who applied to Ankara Yıldırım Beyazıt University Faculty of Dentistry Oral and Maxillofacial Radiology Clinic for various reasons and required panoramic radiography for diagnostic purposes, were included in the study.

Exclusion criteria were determined as individuals under the age of 15, congenital systemic diseases and syndromes, the presence of pathologies that may affect the maxillofacial region, history of any surgery or trauma in the head region, lack of clear information about third molar tooth, and inadequate radiographic image quality. Informed consent was obtained from the patients included in the study.

Demographic information of the patients, such as age and gender, was recorded. Then, the presence/absence of 3M teeth was noted as a result of detailed anamnesis and clinical examination. All evaluations were supported by records from

the hospital automation system and digital image archive. Agenesis was defined as the absence of tooth mineralization on the panoramic radiograph and the absence of any recorded operation information from the patient's anamnesis and hospital system. In patients with 3M agenesis, the tooth number with agenesis, jaw location (maxilla/mandible) and the number of 3M teeth with agenesis were recorded.

The patients were divided into four different groups according to their date of birth. 1st group 15-22 years old (date of birth 2000-2007), 2nd group 23-32 years old (date of birth 1990-1999), 3rd group 33-42 years old (date of birth 1980-1989), 4th group was determined as those aged 43 and over (date of birth in 1979 and earlier).

All radiographs were taken with the same orthopantomography device (Planmeca Promax, Helsinki, Finland; irradiation parameters 64-70 kVp, 6-12.5 mA, 15-16s). Clinical examination of the patients, detailed anamnesis information and all radiographic image evaluations were performed by an Oral and Maxillofacial Radiologist (B.Ç) with at least 6 years of experience.

The statistical software program SPSS version 26.0 (SPSS Inc., Chicago, IL, USA) was used for data analysis. Fundamentals characteristics were summarized as frequencies and percentages for categorical variables. Pearson's chi-square test was used to analyze the relationships between categorical variables. P< .05 was accepted as statistically significant values.

Results

In this study, 1479 patients aged between 15 and 83 years (36.07±14.54) were examined. 905 patients were female (61.2%) and 574 were male (38.8%). When the presence of 3M agenesis was evaluated, 374 patients (25.3%) had agenesis in one or more 3M teeth, while no agenesis was found in 1105 patients (74.7%) (Table 1). There were 339 patients (22.9%) aged 15-22 years, 301 patients (20.4%) aged 23-32 years, 390 patients (26.4%) aged 33-42 years, and 449 patients (30.4%) aged 43 years and older.

Table 1 shows the prevalence of 3M agenesis in the study population according to gender and age groups. The prevalence of 3M agenesis was higher in female (26.1%) than in male (24.0%), but this difference was not statistically significant (p = 0.380). The age group in which 3M agenesis was most frequently observed was determined as 23-32 years of age (28.2%). However, there was no statistically significant difference between the groups (p = 0.200) (Table 1).

When evaluated according to tooth numbers, it was observed that agenesis was most common in right maxillary 3M (18) (16.7%), followed by left maxillary 3M (28) (15.6%), right mandibular 3M (48) (12.2%) and left maxillary 3M (38) (11.3%) (18>28>48>38) (Table 2). Of the total 1479 individuals, 4.9% were missing four 3M teeth, 3.7% were missing three 3M teeth, 8.5% were missing two 3M teeth, and 8.2% were missing one 3M tooth (Figure 1).

The distribution of 3M agenesis according to age groups and tooth number was statistically significant only for left maxillary 3M (28) (p=0.038). According to tooth number, the most common tooth with agenesis in the age groups was right maxillary 3M (18) (16.7%). The prevalence rate of agenesis in all 3M teeth was lowest in the 15-22 age group (43.4%, Table 2). There was no significant gender difference, but 3M agenesis was more common in females in both jaws (Table 3).

Table 1. Distribution of 3M agenesis according to gender and age

	Third Molar Agenesis			
	N	**%**	**χ 2**	**p-value**
Gender				
Female	236	26.1		
Male	138	24.0	0.770	.380
Total	374	25.3		
Age groups				
15-22	75	22.1	4.641	.200
23-32	85	28.2		
33-42	107	27.4		
43 and over	107	23.8		
Total	374	25.3		

*N: number of cases. Note: χ2; chi-square test *P<.05; statistically significant.*

Table 2. Distribution of 3M agenesis according to age groups and tooth number

	AGE											
	15-22		**23-32**		**33-42**		**43 and over**		**Total**			
Tooth number	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**χ 2**	**p**
18	41	12.1	53	17.6	74	19.0	79	17.6	247	16.7	7.056	.070
28	36	10.6	53	17.6	66	16.9	76	16.9	231	15.6	8.419	.038*
38	34	10.0	35	11.6	44	11.3	54	12.0	167	11.3	0.815	.846
48	36	10.6	38	12.6	55	14.1	52	11.6	181	12.2	2.311	.510
Total	147	43.4	179	59.5	239	61.3	261	58.1	826	55.8		

*N: number of cases. Note: χ2; chi-square test *P<.05; statistically significant.*

Table 3. Distribution of 3M agenesis according to jaw localization (maxilla/mandible) and gender

	Maxilla		Mandible		χ 2	P value
	N	%	N	%		
Female	191	62.6	151	64.8	0.332	.564
Male	114	37.4	82	35.2	1.524	.217
Total	305	100	233	100		

*N: number of cases. Note: χ2; chi-square test *P<.05; statistically significant*

Table 4. Some previous studies on 3M agenesis in Turkey

Year of Publication	Author Name	Prevalence	Population	Sample size
2010	Çelikoğlu et al.[6]	17.3%	20-26 years	351
2010	Kazanci et al.[9]	23.8%	12-16 years	2579
2011	Topkara ve Sari[8]	23.9%	9-46 years	2761
2017	Kilinç et al.[10]	23.3%	12-18 years	773
2020	Atay et al.[23]	10.3%	9-15 years	1471
2020	Pamukcu et al.[12]	24.9%	12-19 years, 20 and over	1036
	Present study	25.3%	15 years and over	1479

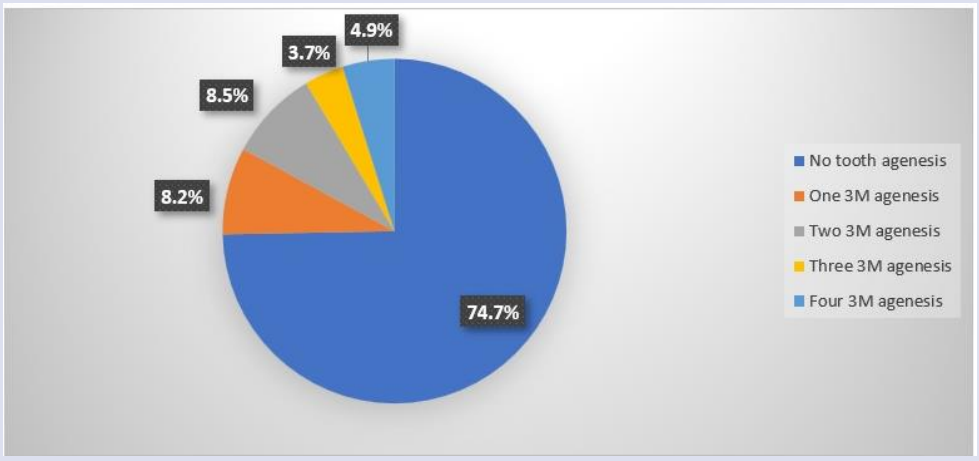

Figure 1: Distribution of the prevalence of 3M agenesis according to the number of deficiency tooth

Discussion

Agenesis is a common anomaly in teeth and occurs more commonly in third molars than in other teeth.[7] This is considered an important issue in both dentistry and anthropology. Tooth development in humans plays a critical role in the evolutionary process.[10] Therefore, understanding the etiology, prevalence and associated factors of agenesis is extremely important for accurate diagnosis and treatment planning.

The prevalence of 3M agenesis has been investigated for many years.[7] It has been emphasized that ethnicity and dietary habits may also cause tooth deficiency.[11,15,16] It has also been argued that there are large differences in the frequency of agenesis depending on the geographical region. In a study, the worldwide rate of 3M agenesis was found to be 22.6%. In previous studies, the lowest rates of 3M agenesis were found to be 0.5% and 1.8% in the Subsaharan-African and Australian aboriginal populations, respectively. In other populations, this rate was reported as 44% in East Asians and Native Americans, 20.9% in South East Asians, and 14.5% in Europeans.[7]

Studies conducted on the prevalence of 3M agenesis in Turkey have shown different rates (Table 4). Among these studies, Kazancı *et al.*[9] reported a 3M agenesis rate of 23.8%, Topkara and Sari[8] reported 23.9%, and Pamukcu *et al.*[12] reported 24.9%. These findings are very close to the 25.3% 3M agenesis rate in the present study. Much of the heterogeneity in the rate of 3M agenesis can be attributed to genetic or environmental variations between populations and between individuals with different numbers of 3M deficiencies.[2]

When the results of the present study were evaluated in terms of gender, although there was no statistically significant difference, the frequency of 3M agenesis was higher in females than in males (Female 26.1%, Male 24.0%). This result can be explained as a result of gender differences in craniofacial morphology. In general, females tend to have smaller dental arch dimensions than males.[17] There are different opinions in the literature regarding the relationship between 3M deficiency and gender. Some studies show that this relationship is statistically insignificant,[6,9,10,16,18,19] while others show that it is significant.[11,15,20-22] At the same time, some studies argue that this deficiency is more common in males.[11,20,21,23,24] Sample sizes, distributions and random variations in the sample may explain all these differences.

There are limited number of studies evaluating different age groups in the literature.[4,12-14] The present study included individuals with a wide age range. The age group with the lowest prevalence of 3M agenesis was the youngest age group (15-22 years). This result may be interpreted as 3M agenesis

decreases over time. Consistent with our findings, the prevalence of 3M agenesis in Japan has decreased slightly in generations born in the 20th century.[13]

Sujon *et al.*[1], Kazanci *et al.*[9], Kilinç *et al.*[10], Pamukcu *et al.*[12], Kaur *et al.*[20] reported that 3M agenesis was more common in the maxilla compared to the mandible. In our study, 3M agenesis in the maxilla was more common in both sexes.

In the present study, agenesis was most common at right maxillary 3M (18) (16.7%), followed by left maxillary 3M (28) (15.6%), right mandibular 3M (48) (12.2%) and left mandibular 3M (38) (11.3%) (18>28>48>38). Consistent with this study, some studies have also reported the regional distribution of the prevalence of 3M agenesis (according to tooth number) as 18>28>48>38.[10,12,22,26] However, there are also studies where the order is different.[1,9,11,15,23]

In this study, the highest frequency of agenesis according to the number of teeth was in individuals with two missing 3M teeth and the order was 2>1>4>3. The present result is consistent with the studies of Endo *et al.*[16], Alam *et al.*[24] In other studies, this situation was reported in different order. Sujon *et al.*[1], Kazanci *et al.*[9], Kilinç *et al.*[10], Pamukcu *et al.*[12] reported an agenesis frequency of 1>2>4>3, Çelikoğlu *et al.*[6], Moreno *et al.*[27] 1>2>3>4, Atay *et al.*[23] 4>1>2>3. According to the results of this study, the rate of individuals with missing four 3M teeth was found to be 4.9%. Previous studies have reported that this rate varies between 3.4% and 5.4% in the Turkish population.[6,8-10,12,23] The results are similar to the present study.

In the patient population, there are a limited number of studies investigating 3M agenesis based on clinical examination-anamnesis.[6,8,12,26] Since most studies have a retrospective design, they usually focus on specific age groups in the patient population. However, in this study, since clinical and radiographic examinations were performed, a wide age range (15-83 years) was included. Thus, different generations were evaluated and false positive evaluations were prevented by confirming that the 3M tooth deficiency is a true agenesis.

Considering the limitations of the current studies, larger, long-term, multidisciplinary studies that include genetic analysis and take into account environmental factors should be conducted to better understand the other causes of 3M tooth agenesis. Such studies may help to improve clinical practice and treatment strategies by providing a more comprehensive perspective.

Conclusions

This study examined the prevalence and distribution of 3M agenesis in a Turkish subpopulation and obtained remarkable findings. In our population of 1479 patients ranging in age from 15 to 83 years, 3M agenesis was 25.3%. There was no significant gender difference in these patients, with a higher prevalence of agenesis in females. There was a higher rate of agenesis in the maxilla compared to the mandible. The age group with at least 3M agenesis was the youngest group. As a result, the reduced incidence of agenesis third molars in the younger generation may be an indicator for understanding the effects on human genetics and environmental factors. It can also have important implications in shaping future research for various aspects of dental research, clinical practice, and public health initiatives.

Conflict of interest

The author has no conflicts of interest to declare.

Funding

The author declared that this study has received no financial support.

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Cumhuriyet Dental Journal, 27(2): 109-117, 2024
DOI: https://doi.org/10.7126/cumudj.1411689

Cumhuriyet Dental Journal

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

Perceptions of Dentists Towards Artificial Intelligence: Validation of a New Scale

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Research Article

History

Received: 29/12/2023
Accepted: 23/02/2024

ABSTRACT

Objective: To enhance the effectiveness and efficiency of using artificial intelligence (AI) in healthcare, it is crucial to comprehend the perceptions of healthcare professionals and individuals regarding AI. This study aimed to: (i) develop and conduct psychometric analyses of a new measurement tool, the AI Perceptions Scale (AIPS); and (ii) identify and compare sub-dimensions of perceptions of AI and its sub-dimensions, specifically in the dental profession.

Materials and Methods: The study used a cross-sectional and correlational design involving 543 dentists. The data collection tools used were a socio-demographic form, the AIPS, and the Dental Profession Perceptions Scale (DPPS). Construct validity was assessed using exploratory and confirmatory factor analysis. Multivariate analysis of variance was utilized to test the difference between AIPS scores among groups.

Results: The AIPS contained 26 items measured on a 5-point Likert response scale and demonstrated excellent internal and test-retest reliability. Exploratory and confirmatory factor analyses of the AIPS identified six factors that categorized perceptions of AI, including 'Human', 'Security', 'Accessibility', 'Vocational', 'Technology', and 'Cost'. The six-factor solution of the AIPS model demonstrated a good fit for the data. AIPS scores varied depending on gender, working place, occupational experience, the need to use AI, and the frequency of AI use in dental practice. The total AIPS score had the strongest correlation with the "human" factor and the weakest correlation with the "accessibility" factor. Statistically significant correlations were observed between the AIPS score and DPPS total, as well as each of its three sub-scales.

Conclusions: This study developed a new scale, the AI Perceptions Scale (AIPS), to evaluate perceptions of AI in healthcare. The perceptions of dentists towards AI were categorized into six distinct factors. The AIPS scale was found to be a reliable and valid measurement tool, indicating that it can be effectively used in future research.

Keywords: Artificial Intelligence, Attitude of Health Personnel, Dentists, Occupational Dentistry, Perception.

Diş Hekimlerinin Yapay Zekâya İlişkin Algıları: Yeni Bir Ölçeğin Geliştirilmesi ve Geçerliliği

Süreç

Geliş: 29/12/2023
Kabul: 23/02/2024

ÖZ

Amaç: Yapay zekanın (yz) sağlık hizmetlerinde kullanımının etkinliğini ve verimliliğini artırmak için, sağlık profesyonellerinin ve bireylerin YZ ile ilgili algılarını anlamak çok önemlidir. Bu çalışmanın amacı: (i) yeni bir ölçüm aracı olan YZ Algılama Ölçeği'nin (YZPS) psikometrik analizlerini geliştirmek ve yürütmek; ve (ii) YZ algılarının alt boyutlarını ve alt boyutlarını, özellikle dişhekimliği mesleğinde belirlemek ve karşılaştırmaktır.

Gereç ve Yöntem: Çalışmada, 543 diş hekimini içeren kesitsel ve korelasyonel bir tasarım kullanıldı. Kullanılan veri toplama araçları sosyo-demografik bir form, YZPS ve Diş Hekimliği Mesleği Algı Ölçeği'dir (DPPS). Yapı geçerliliği açımlayıcı ve doğrulayıcı faktör analizi kullanılarak değerlendirildi. Gruplar arasında YZPS puanları arasındaki farkı test etmek için çok değişkenli varyans analizi kullanıldı.

Bulgular: YZPS, 5 noktalı Likert yanıt ölçeğinde ölçülen 26 madde içeriyordu ve mükemmel dahili ve test-tekrar test güvenilirliği gösterdi. PS'nin açıklayıcı ve doğrulayıcı faktör analizleri, "İnsan", "Güvenlik", "Erişilebilirlik", "Mesleki", "Teknoloji" ve "Maliyet" dahil olmak üzere yapay zeka algılarını kategorize eden altı faktör belirledi. YZPS modelinin altı faktörlü çözümü, veriler için iyi bir uyum gösterdi. YZPS puanları cinsiyete, çalışma yerine, mesleki deneyime, YZ kullanma ihtiyacına ve dişhekimliği pratiğinde YZ kullanım sıklığına bağlı olarak değişti. Toplam YZPS puanı, "insan" faktörü ile en güçlü korelasyona ve "erişilebilirlik" faktörü ile en zayıf korelasyona sahipti. YZPS puanı ile DPPS toplamı ve üç alt ölçeğinin her biri arasında istatistiksel olarak anlamlı korelasyonlar gözlendi.

Sonuçlar: Bu çalışma, sağlık hizmetlerinde yapay zeka algılarını değerlendirmek için yeni bir ölçek olan YZ Algılama Ölçeği (YZPS) geliştirdi. Diş hekimlerinin yapay zekaya yönelik algıları altı farklı faktöre ayrılmıştır. YZPS ölçeğinin güvenilir ve geçerli bir ölçme aracı olması, gelecekte yapılacak araştırmalarda etkin bir şekilde kullanılabileceğini göstermektedir.

Anahtar Kelimeler: Yapay Zeka, Sağlık Personelinin Tutumu, Diş Hekimleri, Işyeri Diş Hekimliği, Algı.

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How to Cite: Buldur B, Teke F, Kurt MA, Sagtas K. (2024) Perceptions of Dentists Towards Artificial Intelligence: Validation of a New Scale, Cumhuriyet Dental Journal, 27(2):109-117.

Introduction

Artificial intelligence (AI) systems have the ability to perceive and respond to events, phenomena, and objects in a manner similar to human intelligence.[1] As AI continues to permeate every aspect of daily life, it has become increasingly important to understand how it is perceived and utilized.[2,3]

The use of AI in dentistry is widespread, particularly in areas such as x-ray and diagnostics[4-6], caries detection[7,8], implantology[9], practice management[10,11], teledentistry[12], and clinical prediction.[13] However, dentists' attitudes toward the use of AI in their profession, as well as the factors that contribute to their willingness or reluctance to use it, are critical to the development of AI algorithms that can enhance the quality of dental practice.[14] The effective implementation of AI tools can significantly improve patient care and optimize daily workflow.[15, 16] However, many dentists are still skeptical about the use of AI in dentistry and view it as a potentially exaggerated trend.[17] This skepticism may be due to negative perceptions of AI, which can lead to negative behavior. Perception and behavior are closely linked, and people's behavior is often influenced by their perceptions.[18]

Understanding the concerns of individuals and the public regarding AI is crucial since these concerns can lead to regulatory activities with potentially severe consequences.[19] While previous literature has primarily focused on future uses of AI, there has been limited research aimed at developing a reliable and valid tool for measuring people's perceptions of AI. However, to the best of our knowledge, no study has examined the sub-components of AI and their relationship with various concomitant factors in dentistry. Given these reasons, developing a measurement tool that assesses people's perceptions of AI and its sub-dimensions can have a significant impact on both clinical and academic aspects.

There are numerous sub-dimensions related to human[20], occupational[21], technological[22], economic[23], security[24,25], accessibility[26], and social factors[27] that can have a positive or negative impact on the use of AI. To enhance the understanding of AI solutions and assess their value, it is crucial to consider these factors. A conceptual model that examines these sub-dimensions together can facilitate the analysis of the factors that may influence them.

The primary objectives of this study were twofold: (i) to develop and conduct psychometric analyses of a novel measurement tool, the AI Perceptions Scale (AIPS); and (ii) to compare and identify sub-dimensions of perceptions of AI with those of the dental profession and its sub-dimensions. The study aimed to answer the following research questions: (i) how do dentists perceive AI; and (ii) do perceptions of AI differ based on factors such as age, gender, education level, working place, occupational experience, income, previous AI education, self-efficacy, necessity to use AI, and frequency of using AI in both daily life and dental practice?

Materials and Methods

Ethical Considerations

This study was conducted in accordance with the ethical standards outlined in the Helsinki Declaration of 1964 and its subsequent amendments. The researchers informed participants that the results would only be used for scientific purposes and that personal data would be kept confidential. Written consent was obtained from all participants.

Study design and participants

This study utilized a cross-sectional and correlational design and was conducted in a province. A convenience sample of 460 practitioners and specialist dentists from various dental specialties who were working in public hospitals, dental faculties, and private clinics were recruited. The study group consisted of dentists working in the city center since most dental patients seek treatment in this area. Additionally, dentists working in the surrounding areas generally prefer not to treat their dental patients. The data collection period took place between July 2022 and September 2022. The participating dentists graduated from different faculties and had varying years of professional experience. Volunteers who were fluent in Turkish were recruited for the study. To assess test-retest reliability, 50 randomly selected participants completed the measurement one month after the initial assessment.

Measurements

The data collection tools that were utilized included three main components: the socio-demographic form, the Artificial Intelligence Perceptions Scale (AIPS), and the Dental Profession Perceptions Scale.

The socio-demographic form

The socio-demographic form contained questions that sought to elicit personal information about the participants, such as their age, gender, education level, monthly income, working experience, working place, previous AI education, and self-efficacy, necessity, and frequency of using AI systems.

The Dental Profession Perceptions Scale

The Dental Profession Perceptions Scale (DPPS) consisted of 17 items, which were measured on a 5-point Likert scale (1=strongly disagree and 5=strongly agree). The DPSS was originally developed in Turkish and English and had good reliability and validity.[28] It addresses participants' perceptions of the dental profession and was built on solid theoretical and psychological bases. The 'Status' factor of the DPPS comprised six items, while the 'Human' factor included seven items, and the 'Scientific' factor consisted of four items. Participants were scored on a scale ranging from 17 to 85.

Artificial Intelligence Perceptions Scale

The development of the Artificial Intelligence Perceptions Scale (AIPS) followed a rigorous methodology

based on existing literature. Initially, a comprehensive literature review was conducted to identify perceptions towards AI. The search was conducted on PubMed, ISI WOS, and Google Scholar databases, using the search terms "artificial intelligence" and "perceptions of artificial intelligence," and limited to English-language peer-reviewed journals. This process resulted in a 44-item draft scale, where each item was rated on a 5-point Likert scale from 1 (Strongly Disagree) to 5 (Strongly Agree). The theoretical model was based on previous AI studies and models, and included sub-dimensions such as "human," "vocational," "technological," "accessibility," "security," and "cost." To ensure face validity, the 44-item scale design was reviewed by an expert team, consisting of a computer engineer, a lecturer from the department of artificial intelligence, and a statistician. The experts provided feedback on the appropriateness of each item for the established conceptual framework, and whether they contained any non-theoretical items. Group discussions with ten participants were also conducted to assess the comprehensibility of the questions and answer options. Based on feedback from the experts and group discussions, seven items were removed from the scale. Finally, two Turkish experts verified the scale, and the final article pool was established.

Statistical Analysis

The data were analyzed using two software programs, SPSS 22.0 (Statistical Package for the Social Sciences) and LISREL 8.51 (Scientific Software International, Lincolnwood, IL USA), with various descriptive statistics calculated. Construct validity was assessed using exploratory factor analysis (EFA) with principal components analysis (PCA) and varimax rotation, and internal reliability was assessed with Cronbach's alpha. Test-retest reliability was assessed with intra-class correlation coefficients (ICCs). The factor structure was then tested using confirmatory factor analysis (CFA) with various fit indexes used to assess the validity of the model. Correlations between different variables were evaluated using Pearson product-moment correlation coefficients. Multivariate analysis of variance (MANOVA) was used to test differences between AIPS scores and socio-demographic and personal characteristics, while independent samples t-tests were used to determine gender differences. The statistical significance level was set at 0.05.[29]

Results

Participants' characteristics

Out of the total 460 participants, 294 (63.9%) were female and 166 (36.1%) were male. The participants were categorized into two groups based on their education level: undergraduate (n=247, 53.7%) and post-graduate (n=213, 46.3%).

Exploratory factor analysis and scale structure

To determine the suitability of the AIPS for factor analysis using PCA, the Kaiser-Meyer-Olkin (KMO) coefficient and Bartlett's sphericity test were used. The data were found to be appropriate for factor analysis, as indicated by the statistically significant KMO value of 0.931 and Bartlett's sphericity test value of $X^2 = 6917.83$, $P<0.01$. After varimax rotation, 11 items were excluded from the scale because their loading factors were shared across two or more factors and/or the loading factor difference was less than 0.10. The final AIPS consisted of 26 items divided into six factors with an Eigenvalue higher than 1. These factors were named as the 'Human', 'Security', 'Accessibility', 'Vocational', 'Technology', and 'Cost' aspects of AI. The 'Human' factor had the highest value (Eigenvalue = 6.44, Cronbach's a = 0.94, % variance explained=24.74) and consisted of nine items examining the characteristics of the human and AI relationship. The 'Security' factor (Eigenvalue=3.23, Cronbach's a = 0.71, % variance explained= 12.42) consisted of three items examining concerns regarding the security of AI. The 'Accessibility' factor (Eigenvalue = 2.26, Cronbach's a = 0.72, % variance explained = 8.70) comprised three items examining sub-dimensions of AI accessibility. The 'Vocational' factor (Eigenvalue = 2.01, Cronbach's a = 0.87, % variance explained = 7.75) comprised five items examining sub-dimensions and characteristics of the vocation and AI relationship. The 'Technology' factor (Eigenvalue = 2.00, Cronbach's a = 0.85, % variance explained = 7.74) consisted of three items examining the technological and scientific sub-dimensions of AI. The final 'Cost' factor (Eigenvalue = 1.86, Cronbach's a = 0.67, % variance explained = 7.17) comprised three items examining the financial aspect of AI. The total variance explained was 68.53%. Table 1 presents the descriptive statistics for each item and the findings of the EFA and reliability analyses. Table 2 shows the final AIPS items and their corresponding factors.

Confirmatory factor analysis

The findings of the Confirmatory Factor Analysis (CFA) conducted on the six-factor model derived from the Exploratory Factor Analysis (EFA) of the AIPS are presented in Figure 1. The analysis indicates that the model fits the data well, with all indices exceeding the recommended value (>0.90), and $\chi 2/df$ values within acceptable limits (<5). The findings demonstrate that the six-factor solution of the AIPS model is a good fit for the data. Figure 1 also displays the path diagram of the six-factor AIPS.

The internal reliability coefficient for the AIPS full scale was determined to be 0.92 using Cronbach's method, which indicates that the scale has a high degree of internal consistency. The corrected item-total correlations for the scale ranged from 0.34 to 0.76, indicating that the items in the AIPS are homogenous. Additionally, the test-retest reliability was also high with an ICC value of 0.91.

Tables 1 and 2 depict the mean scores of each item as well as the distribution of responses from the participants. The item with the highest average score (4.02) on both the AIPS full scale and the Human factor was Item 19, with 84.4% of the participants either strongly agreeing or

agreeing that AI would increase scientific curiosity. On the Security factor, Item 16 received the highest average score (3.40), with 48.0% of respondents either strongly agreeing or agreeing that the use of AI could lead to decision-making problems. The highest average score (2.90) for the items loaded on the Accessibility factor was obtained by Item 17, with 29.3% of participants either strongly agreeing or agreeing that AI could be used in underdeveloped regions. Among the items loaded on the Vocational factor, Item 23 had the highest average score (3.90), with 78.2% of participants either strongly agreeing or agreeing that AI could shorten working hours. For the Technology factor, Item 7 had the highest average score (3.80), with 73.2% of participants either strongly agreeing or agreeing that AI development requires a long time. Finally, among the items loaded on the Cost factor, Item 2 had the highest average score (3.87), with 78.7% of participants strongly or strongly agreeing that AI development needs a long time.

Table 3 displays the Pearson r correlations between the AIPS and its sub-scales with DPPS. The AIPS total score had the strongest correlation with the "human" factor (r = 0.88) and the weakest correlation with the "accessibility" factor (r = 0.44). The Pearson r correlations between the AIPS score and DPPS total and each of its three sub-scales were 0.42, 0.31, 0.41, and 0.40 for the total, status, human, and scientific sub-scales, respectively. All of the Pearson r correlations were statistically significant (P < 0.01).

Table 4 presents a comparison of the sub-scale and total scores of AIPS based on the tested variables. The AIPS scores differed according to variables such as gender, working place, occupational experience, necessity to use AI, and frequency of using AI in dental practice, but there were no significant differences among the other tested variables.

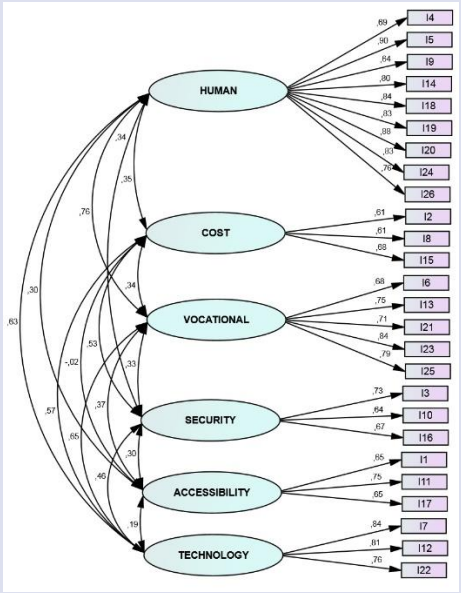

Figure 1: Path diagram of the Confirmatory Factor Analysis (CFA) of the six-factor Artificial Intelligence Perception Scale (AIPS). The fit indices values were as follows: χ2 = 840.20; degrees of freedom (df) = 284; χ2/df = 2.95; p<0.001; Root mean square error of approximation (RMSEA) = 0.0065; Normed fit index (NFI) = 0.88; Non-normed fit index = 0.89; Root mean square residual (RMR) = 0.061; Standardized root mean square residual (SRMR) = 0.066; Comparative fit index (CFI) = 0.91; Relative fit index (RFI) = 0.86; Incremental fit index (IFI) = 0.91.

Table 1. Outcome of the Exploratory Factor Analysis and reliability analyses

Factor and item	Mean	SD	Alpha if item deleted	CITC	Factor loading
Factor 1: Human					
I4 – Alternative to human power	3.78	0.96	0.91	0.62	0.580
I5 – Usability in industry	4.01	0.80	0.91	0.76	0.815
I9 – Human control	3.67	0.91	0.92	0.59	0.481
I14 – Usability in agriculture and livestock	3.79	0.86	0.91	0.69	0.718
I18 – Usability in transportation	3.89	0.86	0.91	0.69	0.746
I19 – Scientific curiosity	4.02	0.83	0.91	0.72	0.720
I20 – Usability in health	3.99	0.80	0.91	0.72	0.801
I24 – Usability in education	3.95	0.84	0.91	0.71	0.722

I26 – Maintaining the ecological balance	3.75	0.84	0.91	0.68	0.647
Factor 2: Security					
I3 – Data security	3.03	0.97	0.92	0.34	0.682
I10 – Ethical concerns	2.46	0.99	0.92	0.34	0.703
I16 – Decision responsibility	3.40	0.92	0.91	0.53	0.630
Factor 3: Accessibility					
I1 – Easily accessibility	2.64	0.93	0.92	0.31	0.663
I11 – Usability with(out) internet	2.89	0.99	0.92	0.38	0.590
I17 – Usability in underdeveloped regions	2.90	1.02	0.92	0.38	0.722
Factor 4: Vocational					
I6 – New job opportunities	3.76	0.86	0.92	0.60	0.579
I13 – Reputation of profession	3.55	0.92	0.81	0.60	0.683
I21 – Customer satisfaction	3.69	0.84	0.91	0.60	0.628
I23– Working hours	3.90	0.80	0.91	0.67	0.728
I25 – Financial income	3.77	0.82	0.91	0.73	0.675
Factor 5: Technology					
I7 – Development process	3.80	0.87	0.91	0.65	0.795
I12 – Large teams	3.71	0.92	0.92	0.57	0.796
I22 –Need for high energy	3.56	0.91	0.92	0.56	0.761
Factor 6: Cost					
I2 – Expensive products	3.87	0.91	0.91	0.37	0.652
I8 – Costly using	3.07	1.00	0.92	0.32	0.725
I15 –Requiring expensive hardware	3.51	0.94	0.91	0.37	0.607

Table 2. Responses to the Artificial Intelligence Perceptions Scale (AIPS) items

How much do you agree with the following statements?	Strongly	Disagree	Neither	Agree	Strongly
	n (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)
1) Artificial intelligence-based products are easily accessible.	45 (9.8)	168 (36.5)	162 (35.2)	77 (16.7)	8 (1.7)
2) Artificial intelligence-based products can be expensive.	15 (3.3)	25 (5.4)	58 (12.6)	266 (57.8)	96 (20.9)
3) Using artificial intelligence can endanger data and information	27 (5.9)	101 (22.0)	187 (40.7)	117 (25.4)	28 (6.1)
4) Artificial intelligence-based systems can be an alternative to	18 (3.9)	28 (6.1)	82 (17.8)	241 (52.4)	91 (19.8)
5) Artificial intelligence can be used in industry.	7 (1.5)	18 (3.9)	49 (10.7)	274 (59.6)	112 (24.3)
6) Using artificial intelligence can create new job opportunities.	14 (3.0)	53 (11.5)	172 (37.4)	175 (38.0)	46 (10.0)
7) The development process of artificial intelligence can take a long	9 (2.0)	31 (6.7)	83 (18.0)	255 (55.4)	82 (17.8)
8) Using artificial intelligence-based products can be costly and	23 (5.0)	125 (27.2)	129 (28.0)	161 (35.0)	22 (4.8)
9) Human control and oversight of artificial intelligence can make	15 (3.3)	29 (6.3)	109 (23.7)	243 (52.8)	64 (13.9)
10) Using artificial intelligence in professional life may be unethical.	80 (17.4)	166 (36.1)	145 (31.5)	58 (12.6)	11 (2.4)
11) Artificial intelligence can also be used without an internet	36 (7.8)	126 (27.4)	171 (37.2)	105 (22.8)	2 (4.8)
12) Large teams may be needed for the development of artificial	12 (2.6)	35 (7.6)	103 (22.4)	234 (50.9)	76 (16.5)
13) Using artificial intelligence can increase the reputation of the	13 (2.8)	44 (9.6)	134 (29.1)	213 (46.3)	56 (12.2)
14) Artificial intelligence can be a solution to problems in	12 (2.6)	21 (4.6)	95 (20.7)	255 (55.4)	77 (16.7)
15) High-level and costly hardware may be required to use artificial	13 (2.8)	56 (12.2)	123 (26.7)	217 (47.2)	51 (11.1)
16) The use of artificial intelligence can create problems about the	14 (3.0)	53 (11.5)	172 (37.4)	175 (38.0)	46 (10.0)
17) Artificial intelligence can also be used in underdeveloped or	41 (8.9)	125 (27.2)	153 (33.3)	121 (26.3)	20 (4.3)
18) Artificial intelligence can be a solution to the problems that	10 (2.2)	24 (5.2)	66 (14.3)	265 (57.6)	95 (20.7)
19) Artificial intelligence can increase scientific curiosity.	8 (1.7)	20 (4.3)	44 (9.6)	269 (58.5)	119 (25.9)
20) Artificial intelligence can be used in the field of health.	6 (1.3)	20 (4.3)	53 (11.5)	272 (59.1)	109 (23.7)
21) Artificial intelligence can improve the quality of relationships	8 (1.7)	32 (7.0)	114 (24.8)	246 (53.5)	60 (13.0)
22) Artificial intelligence-based products can use high energy.	11 (2.4)	47 (10.2)	125 (27.2)	223 (48.5)	54 (11.7)
23) Using artificial intelligence can shorten working hours or	6 (1.3)	22 (4.8)	72 (15.7)	271 (58.9)	89 (19.3)
24) Artificial intelligence can be used in the field of education.	11 (2.4)	18 (3.9)	55 (12.0)	269 (58.5)	119 (25.9)
25) Using artificial intelligence can increase financial income.	4 (0.9)	30 (6.5)	104 (22.6)	248 (53.9)	74 (16.1)
26) Using artificial intelligence can be beneficial in maintaining the	11 (2.4)	18 (3.9)	113 (24.6)	249 (54.1)	69 (15.0)

Table 3. Correlations between the AIPS scale score with sub-factor scores and DPPS scale score with sub-factor scores

Measure	1	2	3	4	5	6	7	8	9	10	11
1. AIPS – Total	-	0.88	0.54	0.44	0.81	0.73	049	0.42	0.31	0.41	0.40
2. AIPS – Human		-	0.29	0.26	0.70	0.55	0.27	0.41	0.23	0.43	0.44
3. DPPS – Security			-	0.23	0.26	.37	0.38	0.17	0.18	0.16	0.09
4. DPPS – Accessibility				-	0.31	0.16	0.01	0.09	0.16	0.03	0.02
5. AIPS – Vocational					-	0.54	0.25	0.34	0.23	0.33	0.34
6. AIPS – Technology						-	0.43	0.33	0.26	0.31	0.29
7. AIPS – Cost							-	0.28	0.23	0.26	0.23
8. DPPS -Total								-	0.83	0.90	0.88
9. DPPS – Status									-	0.56	0.58
10. DPPS – Human										-	0.79
11. DPPS – Scientific											-

Table 4. Comparison of sub-scale and total scores of AIPS according to tested variables

		Human	Vocational	Technology	Cost	Accessibility	Security	Total
Age (year)	*n*	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)
<25	96	3.9 (3.7 - 4.0)	3.6 (3.5 - 3.8)	3.8 (3.6 - 3.9)	3.5 (3.4 - 3.7)	2.9 (2.8 -3.1)	3.1 (2.9 - 3.3)	3.6 (3.5 - 3.7)
25-35	134	4.0 (3.8 - 4.1)	3.8 (3.7 - 4.0)	3.6 (3.5 - 3.8)	3.4 (3.2 - 3.5)	2.9 (2.7 - 3.0)	2.9 (2.8 - 3.0)	3.6 (3.5 - 3.7)
36-45	86	3.7 (3.6 - 3.8)	3.6 (3.5 - 3.7)	3.6 (3.5 - 3.7)	3.5 (3.4 - 3.7)	2.6 (2.4 - 2.8)	2.9 (2.7 - 3.1)	3.4 (3.3 - 3.5)
46-55	73	3.8 (3.6 - 3.9)	3.7 (3.5 - 3.8)	3.7 (3.5 - 3.8)	3.5 (3.3 - 37)	2.6 (2.4 - 2.8)	2.8 (2.7 - 3.0)	3.5 (3.4 - 3.6)
>55	71	3.8 (3.6 - 3.9)	3.6 (3.4 - 37)	3.6 (3.4 - 3.8)	3.3 (3.2 - 3.5)	2.7 (2.5 -2.9)	2.8 (2.6 -3.0)	3.4 (3.3 - 3.5)
		P = 0.054	*P = 0.051*	*P = 0.094*	*P = 0.204*	*P = 0.017*	*P = 0.094*	*P = 0.069*
Gender								
Women	294	3.8 (3.8 - 3.9)	3.6 (3.6 - 3.7)	3.6 (3.5 - 3.7)	3.5 (3.4 - 3.6)	2.7 (2.6 - 2.8)	2.9 (2.8 - 3.0)	3.5 (3.4 - 3.6)
Men	166	3.8 (3.7 - 3.9)	3.8 (3.7 - 3.9)	3.7 (3.6 -3.8)	3.4 (3.3 - 3.5)	2.8 (2.7 -3.0)	2.9 (2.8 -3.1)	3.5 (3.5 - 3.6)
		P = 0.883	***P = 0.035***	*P = 0.093*	*P = 0.134*	*P = 0.142*	*P = 0.553*	*P = 0.382*
Education level								
Undergraduate	247	3.8 (3.8 - 3.9)	3.7 (3.6 - 3.8)	3.7 (3.6 - 3.8)	3.4 (3.4 - 3.5)	2.8 (2.7 -2.9)	2.9 (2.8 - 3.0)	3.5 (3.5 - 3.6)
Post-graduate	213	3.8 (3.7 - 3.9)	3.7 (3.6 - 3.8)	3.6 (3.5 -3.7)	3.4 (3.3 - 3.5)	2.7 (2.6 - 2.8)	2.9 (2.8 - 3.0)	3.5 (3.4 - 3.6)
		P = 0.675	*P = 0.823*	*P = 0.384*	*P = 0.830*	*P = 0.592*	*P = 0.613*	*P = 0.612*
Working place								
Public	130	3.9 (3.8 - 4.1)a	3.7 (3.6 - 3.9)	3.7 (3.6 -3.9)	3.6 (3.4 -3.7)	2.7 (2.6 -2.9)	3.0 (2.9 - 3.1)	3.6 (3.5 - 3.7)
University	207	3.8 (3.7 - 3.9)	3.7 (3.6 - 3.8)	3.6 (3.5 -3.7)	3.4 (3.3 -3.5)	2.8 (2.7 - 2.9)	2.9 (2.8 - 3.0)	3.5 (3.4 - 3.6)
Private Clinic	123	3.7 (3.6 -3.9)a	3.7 (3.5 -3.7)	3.6 (3.4 -3.7)	3.4 (3.3 -3.5)	2.7 (2.6 - 2.9)	2.8 (2.7 - 2.9)	3.4 (3.3 - 3.5)
		P = 0.042	*P = 0.669*	*P = 0.286*	*P = 0.085*	*P = 0.631*	*P = 0.060*	*P = 0.062*
Occupational experience(yr)								
1-5	127	3.9 (3.8 - 4.0)	3.8 (3.6 -3.8)	3.7 (3.6 - 3.8)	3.4 (3.3 - 3.6)	2.8 (2.7 - 2.9)	3.0 (2.9 - 3.1)	3.6 (3.5 - 3.7)
6-10	116	3.8 (3.7 - 4.0)	3.7 (3.6 - 3.8)	3.6 (3.4 - 3.7)	3.4 (3.2 - 3.5)	2.9 (2.7 - 3.0)	2.8 (2.7 - 3.0)	3.5 (3.4 - 3.6)
11-15	120	3.7 (3.6 - 3.8)	3.6 (3.4 - 3.7)	3.5 (3.4 -3.6)a	3.4 (3.3 - 3.6)	2.6 (2.5 - 2.8)	2.8 (2.6 - 2.9)a	3.4 (3.3 - 3.5)
>16	97	3.9 (3.7 -4.0)	3.7 (3.6 - 3.9)	3.8 (3.7 - 4.0)b	3.6 (3.4 - 3.7)	2.7 (2.6 - 2.9)	3.1 (3.0 -3.3)b	3.6 (3.5 - 3.7)
		P = 0.120	*P = 0.174*	***P = 0.010***	*P = 0.266*	*P = 0.077*	***P = 0.003***	*P = 0.019*
Monthly income (TL)								
<10,000	98	3.8 (3.7 - 3.9)	3.6 (3.5 - 3.8)	3.7 (3.6 - 3.9)	3.6 (3.4 - 3.7)	2.8 (2.6 - 3.0)	2.9 (2.8 - 3.1)	3.5 (3.4 - 3.6)
10,001-20,000	123	3.8 (3.7 - 3.9)	3.7 (3.6 -3.8)	3.6 (3.4 -3.7)	3.5 (3.3 - 3.6)	2.8 (2.6 - 2.9)	2.9 (2.7 - 3.0)	3.5 (3.4 - 3.6
20,001 - 30,000	115	3.9 (3.8 - 4.0)	3.8 (3.7 - 3.9)	3.6 (3.5 - 3.8)	3.4 (3.3 - 3.5)	2.8 (2.6 - 2.9)	3.0 (2.8 - 3.1)	3.6 (3.5 - 3.7)
30,001 - 40,000	82	3.8 (3.7 - 4.0)	3.6 (3.5 -3.8)	3.6 (3.5 -3.8)	3.4 (3.2 - 3.5)	2.6 (2.4 - 2.8)	2.9 (2.7 - 3.1)	3.5 (3.3 - 3.6)
>40,000	42	3.8 (3.6 - 4.0)	3.7 (3.5 - 3.9)	3.8 (3.5 - 4.0)	3.3 (3.1 - 3.5)	2.8 (2.6 - 3.1)	3.0 (2.8 - 3.3)	3.5 (3.4 - 3.7)
		P = 0.714	*P = 0.338*	*P = 0.517*	*P = 0.196*	*P = 0.428*	*P = 0.798*	*P = 0.692*
Previous AI education								
Yes	10	3.9 (3.4 - 4.3)	3.9 (3.5 - 4.4)	3.7 (3.2 - 4.2)	3.4 (2.9 - 3.8)	2.7 (2.2 - 3.1)	3.2 (2.7 - 3.7)	3.6 (3.3 - 3.9)
No	450	3.8 (3.8 - 3.9)	3.7 (3.6 - 3.7)	3.6 (3.6 - 3.7)	3.4 (3.4 - 3.5)	2.8 (2.7 - 2.8)	2.9 (2.8 - 3.0)	3.5 (3.5 - 3.6)
		P = 0.797	*P = 0.264*	*P = 0.772*	*P = 0.812*	*P = 0.652*	*P = 0.275*	*P = 0.600*
Self-efficacy to use AI								
Yes	76	3.9 (3.7 - 4.0)	3.7 (3.6 - 3.9)	3.6 (3.4 - 3.8)	3.3 (3.1 - 3.4)	2.9 (2.7 - 3.1)	2.8 (2.6 - 3.0)	3.5 (3.4 - 3.6)

No	210	3.8 (3.7 - 3.9)	3.7 (3.6 - 3.8)	3.7 (3.6 - 3.8)	3.6 (3.5 - 3.7)	2.7 (2.6 - 2.8)	3.0 (2.9 - 3.1)	3.5 (3.5 - 3.6)
Neutral	174	3.8 (3.7 - 3.9)	3.7 (3.5 - 3.8)	3.6 (3.5 - 3.7)	3.4 (3.3 - 3.5)	2.8 (2.7 - 2.9)	2.9 (2.8 - 3.0)	3.5 (3.4 - 3.6)
		P = 0.846	*P = 0.587*	*P = 0.139*	*P = 0.003*	*P = 0.054*	*P = 0.136*	*P = 0.629*
Necessity to use AI								
Yes	245	3.9 (3.8 - 4.0)a	3.8 (3.7 - 3.9)a	3.7 (3.6 - 3.8)	3.4 (3.4 - 3.5)	2.9 (2.8 - 3.0)a	2.9 (2.8 - 3.0)	3.6 (3.5 - 3.6)a
No	52	3.4 (3.2 - 3.6)b	3.3 (3.1 - 3.5)b	3.5 (3.3 - 3.7)	3.5 (3.3 - 3.7)	2.5 (2.2 - 2.7)b	3.1 (2.9 - 3.4)	3.3 (3.1 - 3.4)b
Neutral	163	3.8 (3.7 - 3.9)a	3.6 (3.5 - 3.7)c	3.6 (3.5 - 3.7)	3.4 (3.3 - 3.5)	2.7 (2.6 - 2.8)	2.9 (2.8 - 3.0)	3.5 (3.4 - 3.6)a
		P = 0.001	***P = 0.001***	*P = 0.482*	*P = 0.532*	***P = 0.002***	*P = 0.053*	***P = 0.001***
Frequency of using AI in daily life								
Never	100	3.7 (3.5 - 3.8)	3.6 (3.4 - 3.7)	3.5 (3.4 - 3.7)	3.6 (3.4 - 3.7)	2.6 (2.4 - 2.8)	2.9 (2.8 - 3.19	3.4 (3.3 - 3.5)
Rarely	132	3.8 (3.7 - 4.0)	3.7 (3.6 - 3.8)	3.7 (3.6 - 3.9)	3.5 (3.3 - 3.6)	2.8 (2.7 - 2.9)	3.0 (2.9 - 3.1)	3.5 (3.5 - 3.6)
Sometimes	164	3.8 (3.7 - 4.0)	3.7 (3.6 - 3.8)	3.7 (3.5 - 3.8)	3.4 (3.3 - 3.5)	2.8 (2.7 - 2.9)	2.9 (2.8 - 3.0)	3.5 (3.4 - 3.6)
Often	54	4.0 (3.8 - 4.2)	3.9 (3.7 - 4.0)	3.6 (3.4 - 3.9)	3.3 (3.1 - 3.5)	2.8 (2.6 - 3.1)	2.8 (2.6 - 3.0)	3.6 (3.4 - 3.7)
Always	10	4.1 (3.6 - 4.5)	4.1 (3.7 - 4.6)	3.9 (3.4 - 4.3)	3.3 (2.8 - 3.7)	3.0 (2.5 - 3.4)	3.0 (2.5 - 3.5)	3.7 (3.4 - 4.0)
		P = 0.058	*P = 0.056*	*P = 0.323*	*P = 0.189*	*P = 0.193*	*P = 0.738*	*P = 0.119*
Frequency of using AI in dental practice								
Never	238	3.8 (3.7 - 3.9)	3.7 (3.6 - 3.8)	3.7 (3.6 - 3.8)	3.5 (3.4 - 3.8)	2.6 (2.8 - 3.0)c	2.9 (2.8 - 3.0)	3.5 (3.4 - 3.6)
Rarely	135	3.8 (3.7 - 4.0)	3.7 (3.6 - 3.8)	36 (3.4 - 3.7)	3.3 (3.2 - 3.4)	2.9 (2.8 - 3.1)c	2.9 (2.8 - 3.0)	3.5 (3.4 - 3.6)
Sometimes	62	3.8 (3.7 - 4.0)	3.7 (3.5 - 3.8)	3.7 (3.5 - 3.9)	3.4 (3.2 - 3.6)	2.9 (2.7 - 3.1)c	3.0 (2.8 - 3.2)	3.5 (3.4 - 3.7)
Often	14	3.9 (3.5 - 4.3)	4.0 (3.6 - 4.4)	3.7 (3.3 - 4.1)	3.3 (2.9 - 3.6)	3.3 (2.9 - 3.7)a	2.5 (2.1 - 2.9)	3.6 (3.3 - 3.9)
Always	10	2.7 (1.3 - 4.1)	3.0 (1.6-4.3)	3.0 (1.4 - 4.5)	4.3 (2.8 - 4.7)	4.0 (2.4 - 4.5)b	3.3 (1.8 - 4.8)	3.2 (2.2 - 4.2)
		P = 0.574	*P = 0.369*	*P = 0.690*	*P = 0.052*	***P = 0.001***	*P = 0.251*	*P = 0.900*

Discussion

The primary objective of this research was to create and evaluate the psychometric properties of the Artificial Intelligence Perceptions Scale (AIPS) in a Turkish dentist population. The study examined both the reliability and validity of the AIPS. The results indicated that the AIPS exhibited high internal consistency and test-retest reliability. The AIPS items also demonstrated good validity in terms of test score interpretations and correlations with perceptions of the dental profession. In general, the participants viewed AI as having higher scores in the human, vocational, technology, and cost components, while scoring lower in the accessibility and security components.

This research paper outlines the creation of a new scale using recommended scale development techniques from the literature. The study includes analyses of explanatory and confirmatory factor analysis, as well as validity and reliability of the scale. The findings suggest that the AIPS, which is based on a six-factor structure derived from previous literature, is a valid and reliable research tool for measuring perceptions of AI. The internal reliability coefficient of the AIPS exceeded the recommended values. While research on AI perception and related factors has been limited, to the authors' knowledge, there is currently no valid and reliable scale available for assessing perceptions of AI. Therefore, the AIPS can be used to evaluate professional perceptions of AI in relation to their field and/or to determine personal, professional, or public perceptions of AI.

This research paper makes several important contributions. Firstly, the AIPS can be used as a measurement tool in future studies and in different cultural contexts. Secondly, the scale is psychometrically robust, demonstrating both reliability and validity. In previous studies[30,31] that examined perceptions of AI, validity and reliability were not tested or the scales used were too long, making them impractical measurement tools. Some studies[19,32] also had low construct validity and did not directly measure perceptions of AI. In contrast, the AIPS can be used in future studies due to its advantages, such as the possibility of conducting detailed factor analysis and investigating psychometric properties, as well as being a short and simple tool that can be easily completed by participants.

The study was conducted only among dentists in a province, which limits the generalizability of the findings to other healthcare professionals or to different cultural contexts. Furthermore, the study relied on self-report measures, which may be subject to response bias or social desirability bias. Finally, the study did not assess the actual use of AI in dental practice, which could provide valuable insights into how perceptions of AI relate to its practical implementation in the field.

Understanding the multidimensional nature of AI perception is indeed crucial, as the perception of AI can impact its adoption and integration in various fields. The factors identified in this study, such as human, security, accessibility, vocational, technology, and cost, are consistent with previous literature[2,5,6,10,11,13,17,33], indicating the robustness of the findings. However, as mentioned earlier, further research is needed to examine the impact of psychological factors and independent professional or personal variables on AI perception. Innovations, including technological, political, demographic, and economic trends, have the potential to change perceptions of AI.[34] Over time, this relationship between AI and personal, vocational, and social orientation and mobility has varied. Therefore, understanding the multidimensional nature of AI perception and determining it with a valid and reliable measurement tool with appropriate factors is crucial and critical. Additionally, future studies could

explore the potential changes in AI perception due to ongoing technological, political, demographic, and economic trends.

It is important to note that the lower agreement scores in the accessibility and security factors do not necessarily mean that the participants have negative perceptions of AI in these aspects. Rather, it may reflect the uncertainty or lack of knowledge about these aspects[35], which could be addressed through education and training. As the use of AI in healthcare continues to grow, it is crucial for healthcare professionals to have a clear understanding of its benefits and potential risks in order to provide safe and effective care to their patients. Therefore, further research and education efforts are needed to better understand and address the concerns and perceptions of healthcare professionals regarding AI.

Although there was no variation in the results of other tested factors, AIPS scores were found to be influenced by certain variables such as gender, place of work, vocational experience, the need to use AI, and the frequency of AI usage in dental practice. The results indicate that men scored significantly higher in the "vocational" category compared to women. This may be associated with the fact that men tend to use technology more frequently than women, both in dental practice and in their daily lives, and are more inclined towards technology.[36] It is possible that dentists working in public settings obtained higher scores in the "human" factor compared to other groups due to their increased exposure to patients and greater interaction with people. Individuals with over 15 years of work experience had higher scores on the "safety" factor in comparison to other groups, as they were concerned about potential security issues related to the use of AI. One possible explanation for this could be that younger dentists use technological products more frequently, but the frequency of usage decreases with age. Dentists who did not perceive the use of AI as necessary had lower scores on the "human", "vocational", and "accessibility" factors, which is in line with the existing literature.

Conclusions

This study developed a new scale, the AI Perceptions Scale (AIPS), to evaluate perceptions of AI in healthcare. The perceptions of dentists towards AI were categorized into six distinct factors. The AIPS scale was found to be a reliable and valid measurement tool, indicating that it can be effectively used in future research. It can also aid in assessing whether these perceptions have an impact on the behavior of professionals.

Acknowledgements

None

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Cumhuriyet Dental Journal, 27(2): 118-126, 2024
DOI: https://doi.org/10.7126/cumudj.1440931

Cumhuriyet Dental Journal

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

Evaluation of the Changes in Condylion-Gonion-Menton Angle and Dentoalveolar Heights After Treatment with Removable Functional Appliances

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Research Article

History

Received: 21/02/2024
Accepted: 03/06/2024

ABSTRACT

Objective: Condylion-Gonion-Menton (CoGoMe) angle and dentoalveolar heights are important parameters that provide information about maxillomandibular growth and development. This study aimed to examine the changes in the CoGoMe angle and dentoalveolar heights after functional treatment and to analyze whether they are related to each other.

Materials and Methods: A total of 60 patients, 38 females (mean age 11.7 ± 0.6) and 22 males (mean age 12.6 ± 0.5), with skeletal class II division I malocclusion caused by mandibular retrognathia and treated with monoblock in the peak period were included. Linear measurements of skeletal angular and dentoalveolar heights were made on lateral cephalograms taken pre- (T0) and post-functional treatment (T1). Paired sample t test, Wilcoxon test and Spearman's rho correlation coefficient were used for statistical analyses. Statistical significance was accepted as $p<0.05$.

Results: While the CoGoMe angle increased significantly with treatment, no significant change was found in the SN/GoGn angle. While no significant change was observed in SNA angle, the increase in SNB and the decrease in ANB were found to be significant. No significant change was observed in anterior dentoalveolar heights. However, increases in posterior dentoalveolar heights were found to be significant. While there was no significant relationship between dentoalveolar heights and CoGoMe angle, dentoalveolar heights showed a positive significant relationship with each other.

Conclusions: It was observed that there was no relationship between the CoGoMe angle and dentoalveolar heights and that the CoGoMe angle was a suitable alternative to the SN/GoGn angle. Since the increases in posterior dentoalveolar heights occur at the dentoalveolar level as a result of selective grinding, it was concluded that dentoalveolar changes should not be neglected while providing skeletal correction for stability in functional orthopedic treatment.

Keywords: Cephalometry, Dentoalveolar Height, Functional, Malocclusion, Orthodontic Appliance.

Hareketli Fonksiyonel Apareylerle Tedavi Sonrası Kondilyon-Gonion-Menton Açısı ve Dentoalveolar Yüksekliklerdeki Değişikliklerin Değerlendirilmesi

Süreç

Geliş: 21/02/2024
Kabul: 03/06/2024

ÖZ

Amaç: Kondilyon-Gonion-Menton (CoGoMe) açısı ve dentoalveolar yükseklikler maksillomandibular büyüme ve gelişme hakkında bilgi sağlayan önemli parametrelerdir. Bu çalışmada fonksiyonel tedavi sonrası CoGoMe açısı ve dentoalveoler yüksekliklerde meydana gelen değişikliklerin incelenmesi ve birbirleriyle ilişkili olup olmadığının analiz edilmesi amaçlanmıştır.

Gereç ve Yöntemler: Çalışmaya mandibular retrognatiden kaynaklanan iskeletsel sınıf II bölüm I maloklüzyona sahip, pik döneminde ve monoblok ile tedavi edilen 38'i kadın (ortalama yaş 11,7 ± 0,6) ve 22'si erkek (ortalama yaş 12,6 ± 0,5) olmak üzere toplam 60 hasta dahil edildi. İskeletsel açıların ve dentoalveoler yüksekliklerin doğrusal ölçümleri, fonksiyonel tedavi öncesi (T0) ve fonksiyonel tedavi sonrası (T1) alınan lateral sefalometrik radyografilerde yapıldı. İstatistiksel analizlerde eşleştirilmiş örneklem t testi, Wilcoxon testi ve Spearman rho korelasyon katsayısı kullanıldı. İstatistiksel anlamlılık $p<0,05$ olarak kabul edildi.

Bulgular: Fonksiyonel tedavi ile CoGoMe açısında anlamlı artış gözlenirken, SN/GoGn açısında anlamlı bir değişiklik saptanmadı. SNA açısında anlamlı bir değişiklik gözlenmezken, SNB'deki artış ve ANB'deki azalma anlamlı bulundu. Anterior dentoalveolar yüksekliklerde anlamlı bir değişiklik gözlenmezken, posterior dentoalveolar yüksekliklerdeki artışların anlamlı olduğu görüldü. Dentoalveolar yükseklikler ile CoGoMe açısı arasında anlamlı bir ilişki bulunmazken, dentoalveolar yükseklikler birbirleriyle pozitif yönde anlamlı ilişki gösterdi.

Sonuçlar: CoGoMe açısı ile dentoalveolar yükseklikler arasında bir ilişki olmadığı ve CoGoMe açısının SN/GoGn açısına uygun bir alternatif olduğu görüldü. Posterior dentoalveoler yüksekliklerdeki artışların selektif möllemeler sonucu dentoalveolar düzeyde gerçekleşmesi nedeniyle, fonksiyonel ortopedik tedavide stabilite için iskeletsel düzelme sağlanırken dentoalveolar değişikliklerin gözardı edilmemesi gerektiği sonucuna varıldı.

Anahtar Kelimeler: Sefalometri, Dentoalveolar Yükseklik, Fonksiyonel, Maloklüzyon, Ortodontik Aparey.

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How to Cite: Cicek O, Erener H, Unal YE. (2024) Evaluation of the Changes in Condylion-Gonion-Menton Angle and Dentoalveolar Heights After Treatment with Removable Functional Appliances, Cumhuriyet Dental Journal, 27(2):118-126.

Introduction

The prevalence of class II malocclusions, which are among the orthodontic anomalies with a high rate in the society, is between 11.9-13 %, and the majority of them consist of class II division I malocclusions with increased overjet.[1,2] It has been stated that these malocclusions, which have been reported to be affected by different etiologies in their development, may result from maxillary prognathia, mandibular retrognathia or both.[3] Panchez and Ruf reported that 20% of the sagittal class II malocclusions are caused by maxillary excess and 80% are caused by mandibular deficiency.[4]

The treatment performed with forces generated using circumferential tissues for the treatment of structural disorders and malpositions of the jaws is functional orthopedics, and the devices used for this purpose are called functional appliances.[5] A wide variety of functional appliances have been developed for Class II treatment. These appliances, which aim to correct the skeletal relationship by positioning the mandible in the advanced, are divided into two as removable and fixed functional appliances. Removable functional appliances have become a frequently used treatment option in skeletal class II division I patients characterized by mandibular retrognathia during the growth period, thanks to the anterior positioning of the mandible.[6] Petrovic *et al.*[7] pointed out that the growth potential of the mandible and its responsiveness to functional orthopedic treatment is strongly affected by the mandibular growth pattern.

The most well-known removable functional appliances include monoblock, twin block, bionator, activator and Frankel 2 appliances. The monoblock was designed by Robin in 1902, and the activator, considered to be the first functional appliance, was developed by Andresen in 1920. Andresen activator is one of the most widely used removable functional appliances thanks to its successful and effective treatment results.[8,9] The advantages of removable functional appliances include their removability, low cost, and easier oral hygiene.[10,11]

Condylion-Gonion-Menton (CoGoMe) angle is one of the important vertical cephalometric measurements that shows the rotational orientation of the mandible and is measured between the condylar axis (Co-Go) and the mandibular base (Go-Me).[12] The CoGoMe angle is an important measurement in functional orthopedic treatments and provides an insight about the response to Class II functional treatment and the direction of vertical growth.[13] Franchi and Baccetti reported that if the CoGoMe angle is less than 125 degrees, a positive response will be obtained to treatment with removable functional appliances, and if it is greater, it will be poor.[14]

It is important that dentoalveolar structures participate in occlusion by forming functional components of the jaws and play a role in establishing vertical jaw relations. Thus, dentoalveolar development affects the vertical features of the face, especially the different growths in the maxillofacial skeleton.[15] In addition, dentoalveolar heights are also affected by the tooth eruption and form the dentoalveolar structure when they come into contact with the opposite. Many studies have shown that the dentoalveolar segment is constantly growing and changing.[16,17] Also, dentoalveolar heights have been reported to be higher in patients with a hyperdivergent growth pattern compared to those with a normodivergent.[15]

When the literature is examined, although there are studies examining the CoGoMe angle and dentoalveolar heights[12,17-19], no study has been found in which these parameters were evaluated after functional orthopedic treatment of skeletal class II division I malocclusions. Since the skeletal and dentoalveolar changes caused by removable functional appliances are critical for orthodontists, it is important to clarify the changes occurring in the CoGoMe angle and dentoalveolar heights with functional treatment and their relationships with each other. Also, SN/GoGn angle is used to evaluate mandibular growth relative to the anterior cranial base and is a classical diagnostic parameter that should be considered before starting orthodontic treatment.[20] However, there is no similar study investigating the potential of the CoGoMe angle as an alternative to the SN/GoGn angle, which provides information about the rotational growth model and is recommended as a predictor in mandibular orthopedic treatments.[18]

Therefore, the aim of this study was to examine the changes in the CoGoMe angle and dentoalveolar heights after the treatment of patients with skeletal class II division I malocclusion in the peak period with removable functional appliances and to clarify whether there is a relationship between the CoGoMe angle and dentoalveolar heights. Additionally, the changes in CoGoMe and SN/GoGn angles will be clarified in the follow-up of mandibular growth and development with functional treatment. The alternative hypothesis of the study is that there is a significant relationship between the CoGoMe angle and dentoalveolar heights.

Material and Methods

The material of the retrospective study consists of patients with skeletal class II division I malocclusion who applied to Zonguldak Bülent Ecevit University, Department of Orthodontics. Ethical approval for the study was received from Zonguldak Bülent Ecevit University Non-Interventional Clinical Research Ethics Committee dated November 22, 2023, with decision number 2023/22-9.

The sample size of the study was carried out with the G*Power program (version 3.1.9.7; Franz Faul, Universität Kiel, Kiel, Germany). Accordingly, considering the mean and standard deviation values of the CoGoMe angle pre- and post-treatment and determining the two-way hypothesis (Tail(s): two), α error probability (α error probe) of 0.05 and the power of the study as 0. 95, the effect size was calculated as 0.47. Accordingly, when at least 50 samples were included, the real power of the study was calculated as 90%. The study included a total of 60 patients who met the following inclusion criterias:

- Having skeletal class II division I malocclusion caused by mandibular retrognathia (maxilla in normal skeletal

sagittal position (SNA:82 ± 2) and ANB angle greater than 4 degrees)

- Having been treated with a single stage functional appliance
- Having normal or low vertical facial skeletal angle
- No prior orthodontic treatment
- Having lateral cephalometric radiographs with high resolution and good image quality
- In pre-treatment; having overjet between 5-8 mm, having treated with a single-stage removable functional appliance, having growth and development in the peak period (MP3 capping)
- In post-treatment; having overjet no more than 3 mm, having class I molar relationship, having completed growth and development (MP3 union)

Patients who did not meet at least one of these criteria were excluded from the study. The sample size by gender, age and functional treatment duration are given in Table 1.

In the first step of the study, lateral cephalometric radiographs taken from the patients' at pre- (T0) and post-functional treatment (T1) using a cephalometric X-ray device (Veraviewepocs 2D, J Morita Mfg. Corp., Kyoto, Japan) were scanned from the clinic archive. Linear and angular measurements made on these lateral cephalograms are as follows: CoGoMe, SN/GoGn, SNA, SNB and ANB skeletal angular measurements; U1/NA and IMPA dental angular measurements; maxillary anterior (MxADH) and posterior (MxPDH) dentoalveolar heights; mandibular anterior (MnADH) and posterior (MnPDH) dentoalveolar heights. After the lateral cephalometric radiographs were transferred to the NemoCeph (Nemotec, 2020, Madrid, Spain) cephalometric analysis program, all measurements were performed by the same researcher.

Table 1. Sample size, age and functional treatment duration data of the patients for gender

		Sample size (N-%)	Age (Mean ±SD)	Functional treatment duration (year)
Gender	Female	38- 63.3 %	11.7 ± 0.6	1.1 ± 0.3
	Male	22- 36.7 %	12.6 ± 0.5	1.4 ± 0.4

SD: Standard deviation, N: sample size, %: percentage

Functional orthopedic treatment protocol

A monoblock removable functional orthopaedic appliance, which is a tooth-borne passive appliance, was applied to the patients. For the production of the appliance, the occlusal bite recording measurement was taken by activating the mandible an average of 7 mm forward sagittally and 3 mm vertically. The appliance opens the bite and has lingual flanges to position the mandible anteriorly. Selective grindings made on the acrylic plate to manage the controlled eruption of the posterior teeth cause clockwise rotation in the occlusal plane, thus improving the class II molar relationship into a class I.[5] Patients were informed about the use and cleaning of the monoblock appliance and the points to be taken into consideration were explained. They were informed that the appliance should be used for 16-18 hours, except for brushing and eating.[21] Patients had control sessions at 4-6 week intervals. During the sessions for all patients, controlled eruptions were performed in the disto-occlusal direction for maxillary molar and in the mesio-occlusal direction for mandibular molars, with selective grindings (average about 2 mm) on the acrylic plate of the appliance in order to achieve Class I molar relationship. Functional orthopedic treatment was completed once it was determined that growth and development were complete on wrist X-rays.[22] Patient cooperation was evaluated by checking whether the advanced mandible relapsed to the initial position when pressure was applied to the chin. Figure 1 illustrates the pre-treatment and post-activation intraoral photographs.

Figure 1: Intraoral photographs of a patient treated with monoblock appliance; (a) lateral bite record photograph taken pre-treatment, (b) lateral bite photograph of the mandible activated advanced by applying the appliance.

Angular and linear parameters measured in the study

Skeletal measurements for maxilla and mandible in the sagittal direction:[23]

- SNA: It is the angle between the lines SN and NA. It shows the sagittal position of the maxilla relative to the anterior cranial base.

- SNB: It is the angle between the lines SN and NB. It shows the sagittal position of the mandible relative to the anterior cranial base.

- ANB: It is the angle between the lines NA and NB. It shows the sagittal position of the maxilla and mandible relative to each other.

Dental angular measurements in maxilla and mandible:

- U1/NA: It is the angle between the upper incisor line and the NA line.

- IMPA: It is the angle between the Go-Me line and the lower incisor line.

Vertical skeletal measurements:[18]

- SN/GoGn: It is the angle between the SN line and the GoGn line.

- Condylion-Gonion-Menton (CoGoMe): It is the angle between the condylar axis line (Co-Go) and the mandibular base (Go-Me).

Measurements for dentoalveolar heights:[12]

- MxADH (Maxillary Anterior Dentoalveolar Height): It is the distance from the incisal edge of the upper central incisor to the palatal line (ANS-PNS).

- MnADH (Mandibular Anterior Dentoalveolar Height) : It is the distance from the incisal edge of the lower central incisor to the mandibular base (Go-Me).

- MxPDH (Maxillary Posterior Dentoalveolar Height): It is the distance from the top of the mesiobuccal cusp of the maxillary first molar to the palatal line (ANS-PNS).

- MnPDH (Mandibular Posterior Dentoalveolar Height): It is the distance from the top of the mesiobuccal cusp of the mandibular first molar to the mandibular base (Go-Me).

The reference lines used:

- ANS-PNS: The line between anterior nasal spina and posterior nasal spina.

- Co-Go: The line between Condylion and Gonion points.

- Go-Me: The line between Gonion and Menton points.

Skeletal and dentoalveolar height measurements investigated in the study are shown in the lateral cephalometric radiograph in Figure 2.

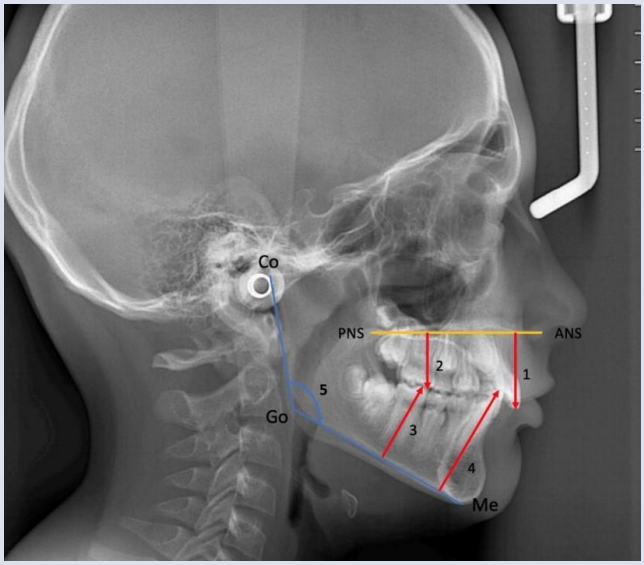

Figure 2: Skeletal and dentoalveolar height measurements; 1; Maxillary anterior dentoalveolar height, 2; Maxillary posterior dentoalveolar height, 3; Mandibular posterior dentoalveolar height, 4; Mandibular anterior dentoalveolar height, 5; Co-Go-Me angle, Co; Condylion, Go; Gonion, Me; Menton, PNS; Posterior nasal spina, ANS; Anterior nasal spina.

Statistical analysis

SPSS (Statistical Package for Social Sciences, version 26, IBM Corporation, NY, USA) program was used for statistical analysis of the data obtained in the study. Normality distribution of the data was evaluated with the one-sample Kolmogorov-Smirnov test. Intra-group comparisons of normally distributed data were made with the paired sample t test, while those with non-normal distribution were evaluated with the Wilcoxon test. The relationship between changes in CoGoMe angle and dentoalveolar height changes was evaluated with Spearman's rho correlation coefficient. The reliability test of the measurements was evaluated with Cronbach's α and two-way random effect intraclass correlation coefficients. Statistical significance level was determined as $p<0.05$.

Results

In order to evaluate intraobserver measurement reliability, excellent reliability was found between measurements made by the same investigator four weeks apart in 15 randomly selected patients (r values were between 0.901 and 0.952 for all measurements).

No significant change was found in the SNA angle with functional treatment ($p>0.05$). On the other hand, the increase in the SNB angle and the decrease in the ANB were found to be statistically significant ($p<0.05$). The SN/GoGn angle also did not change significantly with functional treatment ($p>0.05$). The decrease in the U1/NA angle and the increase in the IMPA were found to be significant ($p<0.05$). It was also found that the CoGoMe angle increased statistically significantly at T1

compared to T0 ($p<0.05$). It was observed that there were no significant changes in both MxADH and MnADH with treatment ($p>0.05$). On the other hand, MxPDH and MnPDH were found to increase significantly after treatment ($p<0.05$). Statistical analysis results for the comparison of measurements at T0 and T1 are given in Table 2.

There was no statistically significant relationship between changes in CoGoMe angle and changes in dentoalveolar heights after removable functional treatment ($p>0.05$). At T1, a moderately positive and statistically significant relationship was found between MxADH change and MxPDH, MxnADH and MnPDH changes ($p<0.05$). Similarly, a moderate positive significant relationship was found between MnADH change and MnPDH and MxPDH changes ($p<0.05$). Again, a moderate positive significant relationship was found between MnPDH change and MxPDH change ($p<0.05$). The results of the correlation analysis of the relationship between CoGoMe angle and dentoalveolar height changes are shown in Table 3. The scatter plots for correlation results are visually shown in Figures 3 and 4.

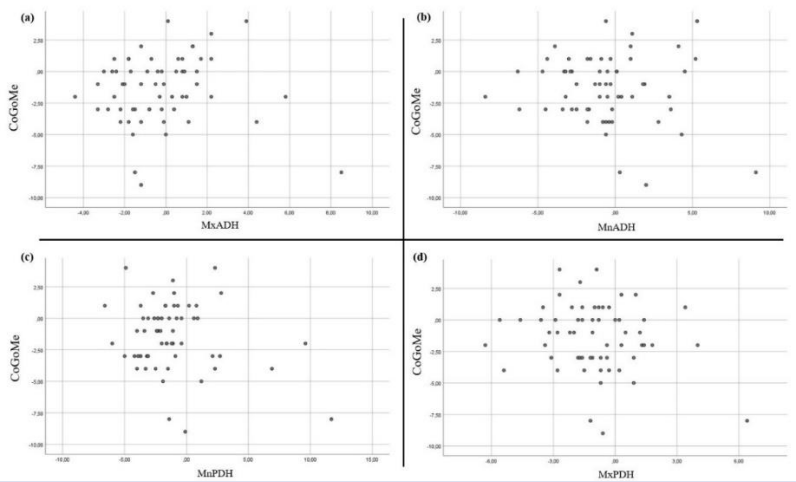

Figure 3: The scatter plots of correlations between the differences in CoGoMe angle and in dentoalveolar heights changes. Scatter plots: (a) for Maxillary Anterior Dentoalveolar Height, (b) for Mandibulary Anterior Dentoalveolar Height, (c) for Mandibulary Posterior Dentoalveolar Height (c), (d) for Maxillary Posterior Dentoalveolar Height.

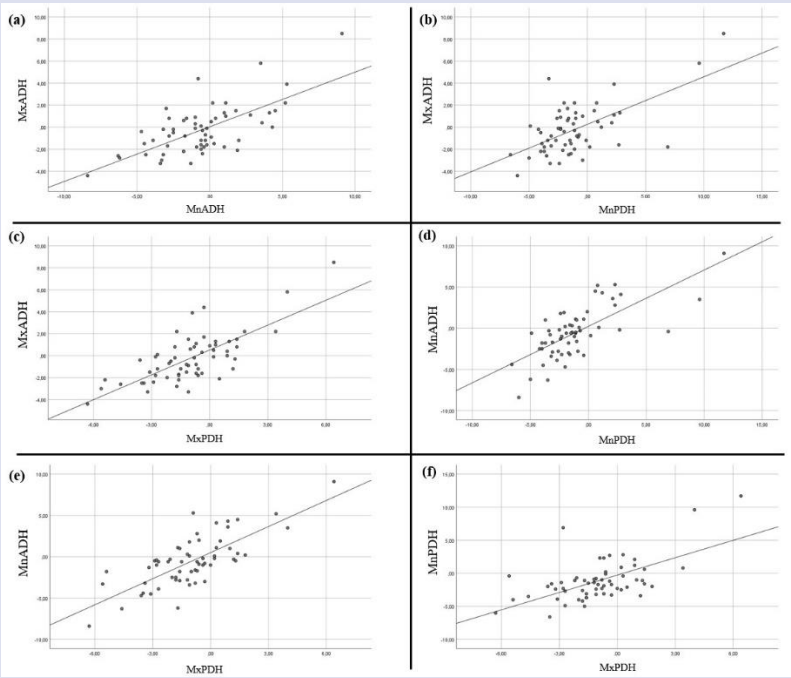

Figure 4: The scatter plots of correlations between the differences in dentoalveolar heights changes. Scatter plots: (a) for the between maxillary and mandibular anterior dentoalveolar height changes, (b) for the between maxillary anterior and mandibular posterior dentoalveolar height changes, (c) for the between maxillary anterior and posterior dentoalveolar height changes, (d) for the between mandibular anterior and posterior dentoalveolar height changes, (e) for the between mandibular anterior and maxillary posterior dentoalveolar height changes, (f) for the between mandibular and maxillary posterior dentoalveolar height changes.

Table 2. Statistical analysis results for angular and linear measurements

		T0	T1	*p*
SNA	Mean±SD	80.88 ± 2.70	80.13 ± 2.36	0.279 [W]
	Median	81	80	
SNB	Mean±SD	75.05 ± 2.64	77.98 ± 2.36	**<0.001 * [P]**
	Median	75	78	
ANB	Mean±SD	5.88 ± 1.05	3.15 ± 1.08	**<0.001 * [W]**
	Median	6	4	
SN/GoGn	Mean±SD	31.70 ± 5.87	32.18 ± 5.64	0.385 [W]
	Median	31.5	30.5	
U1/NA	Mean±SD	32.46 ± 3.43	29.85 ± 3.43	**<0.001 * [W]**
	Median	32	30	
IMPA	Mean±SD	91.48 ± 4.42	94.35 ± 4.39	**<0.001* [W]**
	Median	91	94	
CoGoMe	Mean±SD	124.06 ± 6.09	125.46 ± 5.60	**<0.001* [W]**
	Median	123.5	125	
MxADH	Mean±SD	26.46 ± 3.29	26.71 ± 2.76	0.407 [P]
	Median	26.4	26.7	
MnADH	Mean±SD	37.41 ± 3.77	37.98 ± 3.46	0.158 [P]
	Median	36.6	37.5	
MxPDH	Mean±SD	20.64 ± 2.60	21.65 ± 2.24	**<0.001 * [P]**
	Median	20.4	21.8	
MnPDH	Mean±SD	26.52 ± 3.45	27.69 ± 2.76	**<0.001 * [W]**
	Median	26.05	27.65	

[P]: Paired-t test / [W]: Wilcoxon test / T0: pre-treatment / T1: post-treatment / *p*: significance value / *: $p < 0.05$
MxADH: Maxillary Anterior Dentoalveolar Height / MnADH: Mandibulary Anterior Dentoalveolar Height / MxPDH: Maxillary Posterior Dentoalveolar Height / MnPDH: Mandibulary Posterior Dentoalveolar Height

Table 3. Correlation analysis results of the relationship between CoGoMe angle and dentoalveolar height change amounts

		CoGoMe	MxADH	MnADH	MnPDH	MxPDH
CoGoMe	Spearman rho	1	0.172	-0.058	-0.018	-0.117
	p		0.189	0.661	0.892	0.374
MxADH	Spearman rho		1	0.576	0.422	0.649
	p			**<0.001 ***	**<0.001 ***	**<0.001 ***
MnADH	Spearman rho			1	0.670	0.687
	p				**<0.001 ***	**<0.001 ***
MnPDH	Spearman rho				1	0.494
	p					**<0.001 ***
MxPDH	Spearman rho					1

T0/T1 difference: amount of pre- and post-treatment differences / *p*: significance value / *: $p < 0.05$
MxADH: Maxillary Anterior Dentoalveolar Height / MnADH: Mandibulary Anterior Dentoalveolar Height / MxPDH: Maxillary Posterior Dentoalveolar Height / MnPDH: Mandibulary Posterior Dentoalveolar Height

Discussion

In our study, we examined whether the CoGoMe angle and dentoalveolar heights changed and were related to each other after removable functional orthopedic treatment in patients with Class II division I malocclusion. We found that the CoGoMe angle and posterior dentoalveolar heights in the maxilla and mandible increased significantly with functional treatment. We also found that there was no correlation between the CoGoMe angle and dentoalveolar heights, but dentoalveolar heights showed a significant positive correlation with each other. According to these results, the alternative hypothesis of our study was rejected.

Digital cephalometric radiographs enable fast, accurate and easy diagnosis and follow-up. For this reason, software developed for digital cephalometric analysis that allows measurements on these radiographs has increased considerably.[24] The usability and accuracy of Nemoceph, one of the widely used programs for this purpose, has been reported.[25] However, it has disadvantages such as incorrect head posture and two-dimensional (2D) image magnification.[24] With the development of cone beam computed tomography (CBCT), which eliminated these disadvantages, three-dimensional (3D) imaging began to be used more widely to replace 2D images. However, although CBCTs produce lower radiation exposure than conventional CTs, they create higher radiation exposure than 2D dental radiographs.[26] Considering the follow-up radiographs needed during the long-term treatment of adolescents receiving orthodontic treatment, the potential for adverse effects from receiving CBCT, which will result in exposure to high doses of radiation, is quite high.[24,27,28] For this reason, in our study, the Nemoceph analysis program was used to obtain reliable and repeatable measurements on 2D lateral cephalometric radiographs.

The CoGoMe angle is an important angle related to mandibular rotation, independent of the anterior cranial

base, and its evaluation is important for growth and development monitoring.[12] Dentoalveolar heights are also an important segment in skeletal vertical growth. D'Antò *et al.*[18] investigated the distribution of the CoGoMe angle in a patient population from Southern Italy and the relationship of this angle with vertical and sagittal cephalometric parameters. Contrary to our study, they reported that skeletal sagittal differences did not affect CoGoMe angle and that this angle was associated with vertical facial type. In our study, we found that the CoGoMe angle increased significantly with skeletal mandibular advancement. We think that this is due to sagittal and vertical skeletal changes in the repositioned and advanced mandible. Also, no relationship was observed between CoGoMe angle and dentoalveolar heights.

The average CoGoMe angle measured by growth monitoring by Franchi and Baccetti[14] was reported to be 125.5 degrees. In their study, they reported that the CoGoMe angle is a cephalometric measurement that determines the response to functional treatment before treatment. In our study, we found the average value of the CoGoMe angle to be 124.06 degrees at T0 and significantly increased to 125.46 degrees at T1. In contrast, changes in SN/GoGn angle were not significant. Thus, the significant increases in the CoGoMe angle with functional orthopedic treatment revealed that this angle is an important angular parameter for growth and development monitoring and could be preferred over the SN/GoGn angle in functional treatment.

Martina *et al.*[29] evaluated the relationship between changes in posterior dentoalveolar heights and craniofacial heights. They reported that posterior dentoalveolar heights were positively affected by the change in lower facial heights. In our study, no significant changes were observed in anterior dentoalveolar heights at T1 compared to T0. This situation is thought to be due to the fact that the eruption of the incisors, which is the determinant of the anterior dentoalveolar height, is controlled by the appliance's acrylic plate. However, we found that posterior dentoalveolar heights increased significantly in both jaws after functional treatment. It is thought that this is due to allowing the extrusion of the molars with the selective grindings made on the acrylic plate to create a clockwise rotation in the occlusal plane in order to obtain a class I molar relationship.

In the literature, there are many studies on sagittal skeletal and dental changes that occur with the functional treatment of class II malocclusions.[21,30,31] Dikmen *et al.*[30] observed a decrease in SNA and ANB angles and an increase in SNB angles after functional treatment of class II malocclusions. Additionally, they found both the decrease in U1/NA angle and the increase in IMPA significant. Similarly, in their study investigating the dentofacial effects of functional therapy, Küçükönder *et al.*[31] found the decrease in SNA and ANB angles and the increase in SNB angle significant and observed retroclination in the maxillary incisors and proclination in the mandibular incisors. In our study, we did not find the decrease in SNA angle significant with functional treatment. This is due to the difference in the sample due to the inclusion of patients with a normal sagittal position of the maxilla and the forward displacement of the hard tissue point A, which is affected by the retroclination of the maxillary incisors. However, the increase in the SNB angle, the decrease in the ANB angle, retroclination in the maxillary incisors and proclination in the mandibular incisors were found to be significant.

Laranjo and Pinho[17] stated that dentoalveolar heights are effective in posterior and anterior facial heights and mandibular rotation. They found that maxillary posterior dentoalveolar heights had a strong positive correlation with anterior and posterior facial heights. They also stated that patients with increased dentoalveolar heights had increased vertical growth and the mandible grew in a way that made posterior rotation. In our study, it was observed that maxillary and mandibular posterior dentoalveolar heights increased with the CoGoMe angle at T1, and vertical growth occurred with posterior rotation of the mandible. Additionally, although there were no significant changes in anterior dentoalveolar heights at T1, changes in all dentoalveolar heights were positively significantly correlated with each other.

Ardani *et al.*[32] examined the relationship between dentoalveolar heights and skeletal vertical growth patterns in Indonesian patients with class I malocclusion. They found that maxillary and mandibular posterior dentoalveolar heights were positively correlated with SN/GoGn angle, which are vertical cephalometric measurements. In our study, we found that maxillary and mandibular posterior dentoalveolar heights increased after functional treatment, but this was not related to the CoGoMe angle. We also found that although the SN/GoGn angle increased, this was not significant, but there were significant increases in the CoGoMe angle. It is thought that the differences between the studies are due to the different inclusion criteria of the sample.

The limitations of this study are that multiple comparisons with the literature cannot be made entirely due to the lack of an equivalent study with a similar sample and that the remaining mandibular growth after the post-peak period cannot be monitored long-term. Other limitations include the unequal distribution of male and female patients and the vertical inclusion of only hypodivergent and normodivergent individuals. Furthermore, the effect of different growth patterns could not be evaluated due to the lack of knowledge regarding the distribution of hypodivergent and normodivergent patients in the study group. Therefore, there is a need to plan further studies that include long-term stability follow-ups in appropriate sample groups. With the presented study, important results have been revealed on lateral cephalometric radiographs regarding the changes in the CoGoMe angle and dentoalveolar heights, which are reliable[19,33] and which provide orthodontists with an insight into the level of possible skeletal and dentoalveolar changes expected in the functional treatment of skeletal class II division I malocclusions.

Conclusions

The alternative hypothesis of the study was rejected. The following conclusions were obtained in the research:

- There is no relationship between CoGoMe angle and dentoalveolar heights. On the other hand, the significant positive relationship between changes in dentoalveolar heights was due to changes in dentoalveolar levels.
- In the advanced and repositioned mandible with functional treatment, the eruption of the molars with selective grinding on the acrylic plate and the clockwise rotation in the occlusal plane caused by this resulted in both a class I molar relationship and an increase in posterior dentoalveolar heights. Therefore, orthodontists should not only focus on skeletal correction for stability in functional orthopedic treatment, but should also consider changes at the dentoalveolar level.
- Finally, since significant changes were observed in the CoGoMe angle compared to the SN/GoGn angle with functional treatment, the CoGoMe angle is a suitable alternative to the SN/GoGn angle in monitoring mandibular rotational growth and development changes with functional treatment.

Acknowledgements

The authors declared that this study has received no financial support.

Conflict of Interest

The authors declare no conflict of interest.

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Cumhuriyet Dental Journal, 27(2): 127-135, 2024
DOI: https://doi.org/10.7126/cumudj.1485793

Cumhuriyet Dental Journal

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

Evaluation of the Fractal Dimension in the Apical Region of Primary Teeth with Unilateral and Bilateral Infraocclusion

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Research Article

History

Received: 17/05/2024
Accepted: 24/06/2024

ABSTRACT

Objective: This study aims to employ fractal analysis (FA) to determine potential variations in the mandibular trabecular bone structure in the apical region among individuals with unilateral and bilateral infraocclusion of primary teeth compared to a control group.

Materials and Methods: Forty-three primary teeth identified from panoramic radiographs taken for diagnostic purposes between January 2018 and December 2023 in the Department of Oral, Dental, and Maxillofacial Radiology of our institution were included in this investigation. Categorical variables were analyzed using the chi-square test, while continuous variables were assessed through Student paired t-tests and ANOVA tests. The threshold for statistical significance was set at $p<0.05$.

Results: The analysis revealed that the mean fractal dimension (FD) did not significantly differ between unilateral and bilateral infraocclusion groups based on gender ($p>0.05$). Although the FDs in the apical regions of unilaterally infraoccluded teeth and their contralateral counterparts were observed to be lower, the disparity based on occlusion position did not reach statistical significance (p 0.11). Moreover, no significant distinctions were observed in the FD or resorption levels between teeth exhibiting bilateral infraocclusion on the right and left sides (p: 0.877, p:0.938). It was noted that the presence of an opposing tooth positively influenced the FD; however, this effect did not achieve statistical significance.

Conclusions: While infraocclusion is prevalent in mandibular primary molars, this study did not observe any discernible alterations in the mandibular trabecular bone structure attributable to infraocclusion. Unilateral infraocclusion, in particular, was found to be a common and relatively benign condition. Additionally, numerical anomalies such as hypodontia and supernumerary teeth might exhibit associations with infraocclusion.

Keywords: Fractals, Infraocclusion, Mandibula, Panoramic Radiography,

Unilateral ve Bilateral İnfraoklüzyona Sahip Süt Dişlerinin Apikal Bölgelerindeki Fraktal Boyutun Değerlendirilmesi

Süreç

Geliş: 17/05/2024
Kabul: 24/06/2024

ÖZ

Amaç: Bu çalışmada unilateral ve bilateral infraoklüzyondaki süt dişleri bulunan bireylerin, apikal bölgesindeki mandibular trabeküler kemik yapısının kontrol grubundan farklı olup olmadığının fraktal analiz yöntemi yöntemiyle belirlenmesi amaçlandı.

Gereç ve Yöntemler: Çalışmaya Ocak 2018-Aralık 2023 tarihleri arasında fakültemiz Ağız, Diş ve Çene Radyolojisi Anabilim Dalı'nda teşhis amaçlı çekilen panoramik radyografilerde tespit edilen 43 adet infraoklüze diş dahil edildi. Kategorik değişkenler ki-kare testi kullanılarak analiz edilirken, sürekli değişkenler Students t-testi ve ANOVA testleri kullanılarak değerlendirildi. İstatistiksel anlamlılık eşiği $p<0,05$ olarak belirlendi.

Bulgular: Ortalama fraktal boyut, cinsiyete göre unilateral ve bilateral etkilenme arasında istatistiksel olarak anlamlı bir fark bulunmadı ($p>0,05$). Unilateral infraoklüzyonlu dişlerin apikal bölgelerinde fraktal boyut, karşı taraflarına göre daha düşük olsa da, oklüzyon altındaki konumlarına göre istatistiksel olarak anlamlı bir farklılık bulunmadı (p:0,11). Sağ ve sol tarafta bilateral infraoklüzyonlu dişlerin rezorpsiyon seviyesi ile fraktal boyut arasında istatistiksel olarak anlamlı bir farklılık gözlenmedi (p:0,877, p:0,938). Karşıt arktaki dişin varlığı fraktal boyut üzerinde pozitif bir etki gösterdi, ancak bu etki istatistiksel olarak anlamlı değildi.

Sonuçlar: Bireylerin mandibular süt azı dişlerinde infraoklüzyon sıklıkla görülmektedir. Bireylerde infraoklüzyona bağlı mandibular bölgede trabeküler kemik yapısında değişiklik gözlenmemiştir. Unilateral infraoklüzyon, bireylerde sık görülen hafif bir infraoklüzyon türüdür. Hipodonti ve süpernümerer dişler gibi sayısal anomaliler infraoklüzyon ile ilişkili olabilir.

Anahtar Kelimeler: Fraktal Boyut, İnfraoklüzyon, Mandibula, Panoramik Film.

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How to Cite: Kaya S, Avcı B. (2024) Evaluation of the Fractal Dimension in the Apical Region of Primary Teeth with Unilateral and Bilateral Infraocclusion, Cumhuriyet Dental Journal, 27(2):127-135.

Introduction

Infraocclusion, or submerged tooth, refers to a condition where a tooth is positioned below the occlusal plane. Although several terms are used interchangeably to describe this phenomenon[1], such as ankylosed tooth or impacted tooth, "infraocclusion" is the preferred term for its clinical designation. The etiology of infraocclusion remains uncertain, contributing to the ambiguity in its nomenclature.[1] It is commonly associated with dental ankylosis, where the tooth fuses with the surrounding bone.[2] Infraocclusion can usually be assessed clinically, although radiographic examination may be necessary for definitive diagnosis.[3] It typically occurs when the eruption mechanism fails, resulting in the tooth's inability to maintain its vertical position relative to adjacent teeth[4]. In clinical practice, infraocclusion is commonly categorized into three degrees[5]: mild, moderate, and severe. Mild infraocclusion involves a slight deviation, approximately 1 mm below the occlusal plane of the adjacent tooth. Moderate infraocclusion occurs when the affected tooth aligns at the same level as adjacent teeth' occlusal surface contact points. Severe infraocclusion is characterized by a significant submersion below the interproximal gingival tissue of the adjacent tooth. These classifications are based on the extent of submersion relative to the occlusal plane of neighboring teeth (Figure 1, Figure 2).

Infraocclusion is expected in the mixed dentition phase, especially in the mandibular primary molars[7], where the occlusal surface of these teeth tends to be 0.5-1 mm lower than adjacent teeth. In primary molars affected by infraocclusion, signs such as reduced mobility, metallic percussion sound, displacement of adjacent teeth, and narrowing of the dental arch may be evident.[8] The prevalence of these teeth ranges from 1.3% to 38.5%, varying according to age, gender, and ethnic origin, with the highest prevalence occurring in children aged 6-11 years.[9]

FD analysis is a widely used method for assessing the complexity and irregularity of structures, commonly applied in bone tissue quality evaluation.[10] FD values obtained through the box-counting method typically range from 1 to 2 in trabecular bone. Values nearing 2 indicate a more intricate bone microstructure, while those close to 1 highlight bone porosity, suggesting simpler microstructures.[11] In dentistry, FD analysis aids in detecting early periodontal changes in alveolar bone[12], determining trabecular structure in individuals with hypodontia[13], diagnosing osteoporosis-related pathologies[14], assessing bone tissue near implant sites[15], analyzing patients with temporomandibular joint dysfunction[16], and examining the relationship between disease severity and trabecular bone changes.[16] FA has been applied across various fields, facilitating investigations into complex relationships.[17]

However, the impact of the trabecular bone structure beneath primary teeth affected by infraocclusion has not yet been investigated in the existing literature. Hence, the primary objective of this investigation is to assess potential disparities in the mandibular trabecular bone structure between individuals presenting infraocclusion and a control cohort. This analysis will be conducted employing the FA methodology to discern any notable variations in bone

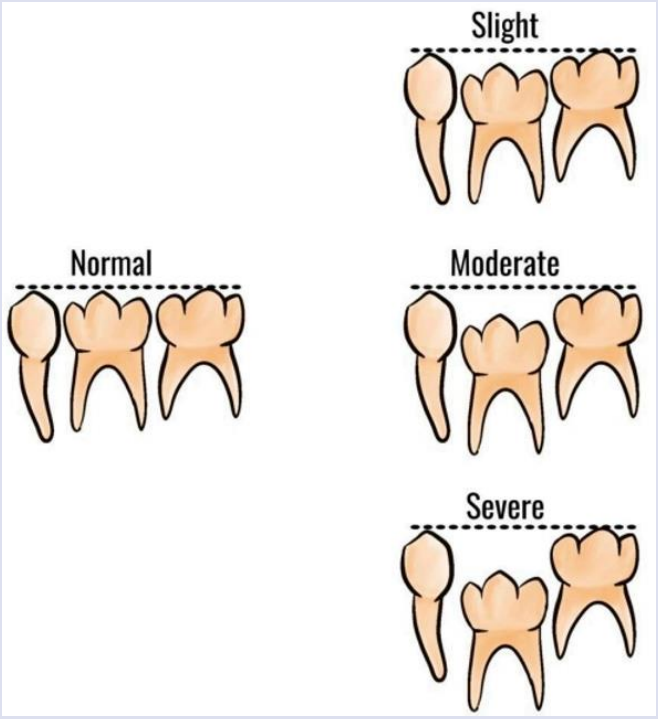

Figure 1: Schematic classification of infraocclusion of primary molars[6].

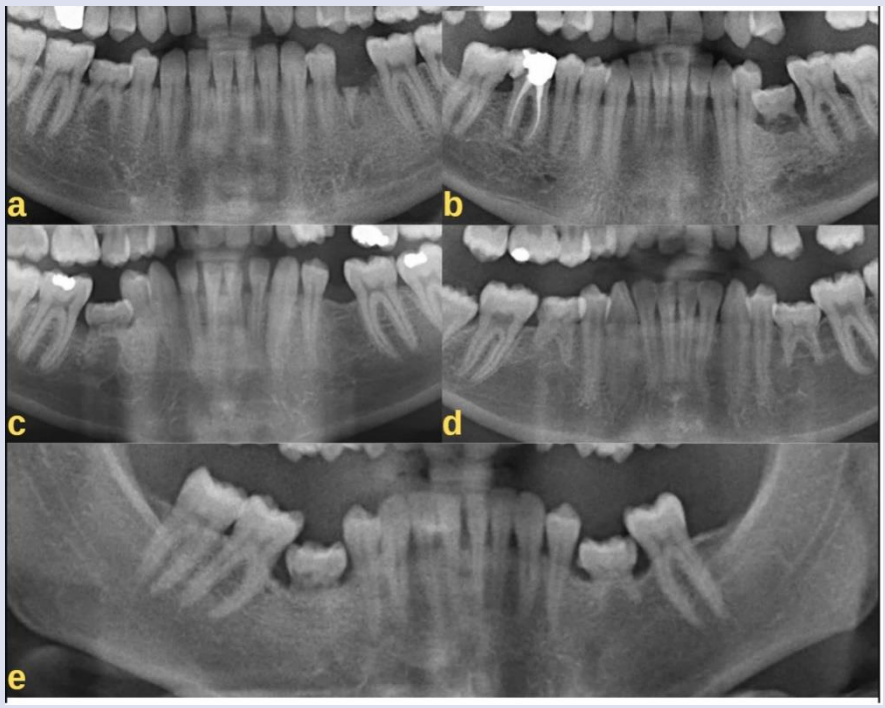

Figure 2: Panoramic radiograph of unilateral and bilateral infraoccluded primary teeth.

Materials and Methods

Samples Selection

This study received approval from the Non-Interventional Clinical Research Ethics Committee on March 21, 2024 (Decision No: 2024/03-21). This retrospective study aligned with the Declaration of Helsinki, ensuring all participants acquired informed consent. The study examined 43 primary infraoccluded teeth identified in panoramic radiographs taken for diagnostic purposes at our faculty's Department of Oral, Dental, and Maxillofacial Radiology between January 2018 and December 2023.

The study enrolled individuals aged 12-30 with permanent or mixed dentition per the inclusion criteria. Exclusion criteria included a history of orthodontic or orthognathic surgery, impacted teeth, root displacement from factors like cyst tumors, craniofacial anomalies, a prior history of trauma or fractures in the mandibular or maxillary regions, and poor-quality panoramic images containing metal or motion artifacts. Additionally, FA was conducted on 28 unilateral infraoccluded teeth and the bone at the apex of the contralateral teeth. The FD in the apical region of 15 bilateral infraoccluded teeth was also evaluated based on the level of resorption, classified as follows: 0: no resorption, 1: 1/3 root resorption, 2: 2/3 root resorption, and 3: complete root resorption. In this study, other dental anomalies seen in the mouth of individuals with infraocclusion will also be examined.

Region of Interest Determination

The panoramic radiographs utilized in this research were captured using the ORTHOPHOS XG device from Sirona, USA, with settings of 60 kV, 3 mA, and an exposure time of 14.1 seconds. Our faculty ensured the routine monitoring and maintenance of these parameters. An experienced oral and maxillofacial radiologist (at least five years) evaluated the images. For FA, two regions of interest (ROI's) were identified. Using the Square tool in ImageJ, a 30 × 30-pixel square was manually drawn around the apex of both the infraoccluded and the contralateral teeth. The radiologist conducted the measurements on a 23-inch computer in a dark room, where panoramic radiographs and tomographic data are typically analyzed, limiting the examination to three hours per day to prevent grayscale sensitivity loss due to prolonged exposure.

Fractal Dimension Examination

The FA procedures in ImageJ adhered to the protocol set forth by White and Rudolph.[18] Each ROI was duplicated post-cropping. A Gaussian filter (sigma, 35) was applied to the duplicated image to eliminate significant brightness variations. The resultant blurred image was then subtracted from the original to accentuate trabecular bone and bone marrow spaces, with an additional 128 gray values added. Subsequently, the image underwent binarization to produce a black-and-white format. Noise was removed via erosion, while dilation sharpened the external lines of the structures. Following image inversion, trabecular bone was represented by black areas and bone marrow spaces by white areas. Skeletonization was then executed. FA involved counting boxes ranging from 2 to 64 pixels on the skeletonized image using ImageJ's Fractal box count plugin (Figure 3). FD values for the apex of

infraoccluded teeth and contralateral teeth ROIs were documented.

Statistical Analysis

The data were analyzed using IBM SPSS V23 (IBM Co., Armonk, NY)—statistics program. The chi-square test was used to compare categorical variables according to group. The effect of resorption level on fractal dimension in bilateral infraoccluded teeth was analyzed by one-way (ANOVA) test since the data were normally distributed according to the Shapiro-Wilk test. The fractal dimension in the apical regions of teeth with unilateral infraocclusion was analyzed using the Paired Student t-test. Analysis results were presented as mean ± standard deviation and median (minimum-maximum) for quantitative data and frequency (percentage) for categorical data. The significance level was taken as $p<0.05$.

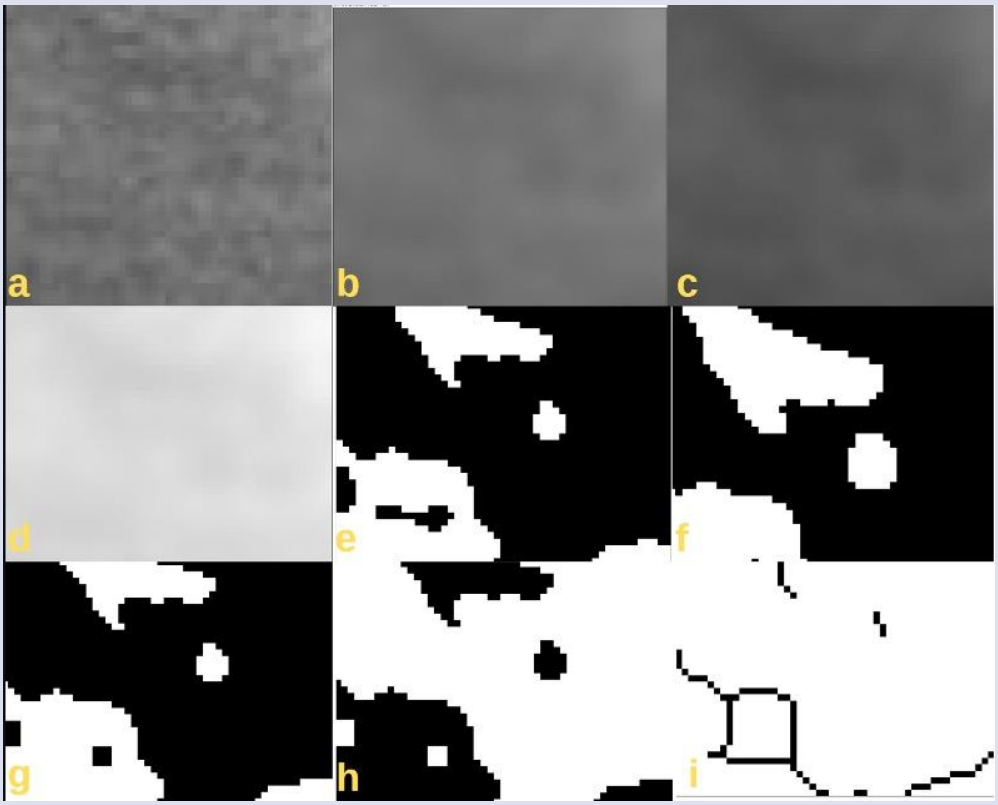

Figure 3: 3a: Duplicated, 3b: Blurred image, 3c: Gaussian filter 3d: Addition of a gray value of 128, 3e: Binarized, 3f: Erode, 3g: Dilate, 3h: Invert 3i: Skeletonize

Results

The study included 58 teeth with infraocclusion, of which 28 (65.1%) were unilateral and 15 (34.9%) were bilateral. Among them, 23 (53.5%) were female and 20 (46.5%) were male. The mean age of the patients was calculated as 21.51±5.39 years. The mean FD and the occurrence of bilateral involvement did not show any significant differences according to gender ($p > .05$) (Table 1). It was noted that the FD in the apical regions of unilateral infraoccluded teeth and their contralateral counterparts was lower. However, no statistically significant difference was based on the position beneath the occlusion (p: 0.11) (Table 2). No statistically significant difference was observed between the resorption and FD levels in bilateral infraoccluded teeth on the right and left sides (p: 0.877, p: 0.938) (Table 3). No statistically significant difference was observed in the FD between unilateral infraoccluded teeth and their contralateral counterparts based on gender (p: 0.86) (Table 4). Other dental anomalies were found in the cases (Figure 4), and the statistical table of distribution according to gender is in Table 5. Furthermore, the presence or absence of a tooth in the contralateral side of unilateral infraocclusion did not show statistically significant differences in the FD, both on the right and left sides, separately (p: 0.832). A contralateral tooth positively affected the FD, although this effect was not statistically significant.

Table 1. Statistical table of fractal dimension in the apices of infraoccluded teeth according to sex.

Gender	N	Mean	Std. Deviation	Std. Error Mean	p*
Female	30	1.0381	.09101	.01662	.184
Male	26	1.0497	.21670	.04250	

** Paired Student T test, FD: Fractal Dimension, Std: Standart, p<0.05.*

Table 2. Statistical table of FD value in the infraoccluded and contralateral tooth apex region.

Region of FD	Mean	N	Std. Deviation	Std. Error Mean	p*
Infraoccluded tooth apex	1.0339	28	.20547	.03883	.11
Contralateral tooth apex	1.0530	28	.10020	.01894	

**Paired Student T test, FD: Fractal Dimension, Std: Standart, p<0.05.*

Table 3. Statistical table of FD value at the apex of the infraoccluded tooth according to the level of root resorption.

	Root Resorption Level (Mean±SD)				
	No Resorption	1/3 Root	2/3 Root	3/3 Root	p**
FD-right	1.06±0.1	1.05±0.11	1.08±0.6	1.04±0.4	.87
FD-left	1.0±0.25	.99±0.29	1.01±0.1	1.05±0.6	.94

**One-Way ANOVA test, FD: Fractal Dimension, p<0.05.

Table 4. Statistical distribution of systematic classification of ınfraocclusion in primary dentition by gender.

Infraocclusion classification	Gender		Total	p*
	Female	Male		
Slightly	8	9	17	.552
Moderate	8	4	12	
Severe	7	7	14	
Total	23	20	43	

* Chi-squared Test, p<.005.

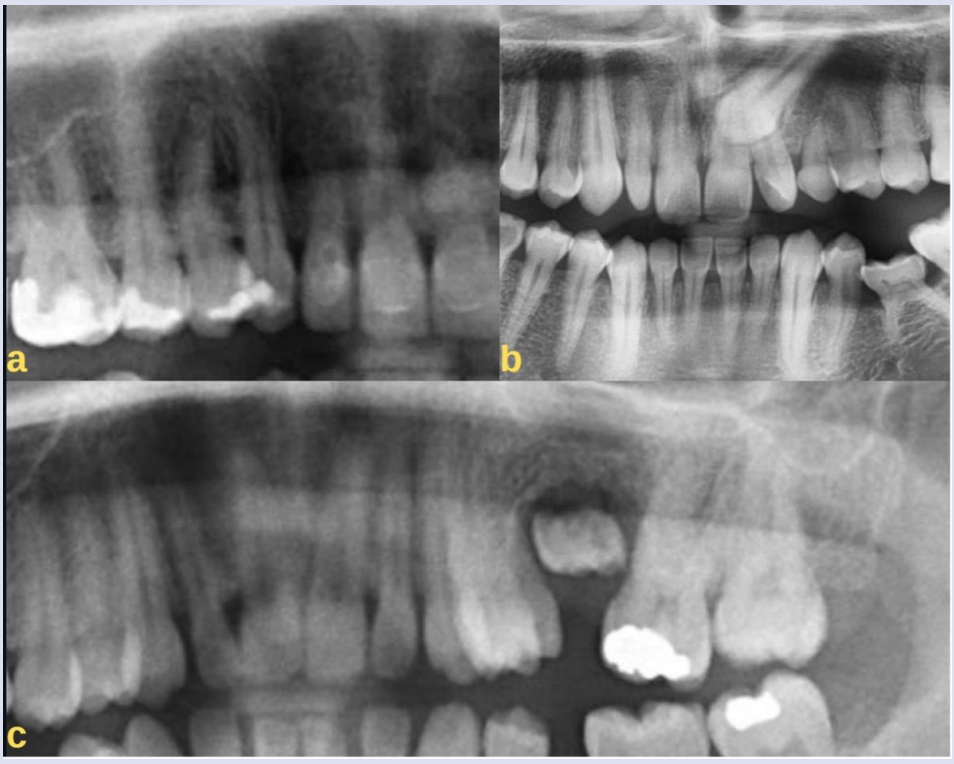

Figure 4: Dental anomalies observed in individuals with infraocclusion. (4a: Dens invaginatus 4b: Microdontia 4c: Tooth agenesis)

Table 5. Table of other dental anomalies found in the cases and statistical distribution table according to gender.

Dental Anomalies	Microdontia	Hypodontia	Dens Invaginatus	Dileseration	p*
Female	1	4	1	1	.692
Male	1	3	1	0	

* Chi-squared Test, p<0.05.

Discussion

While infraocclusion can be diagnosed clinically, evaluating its severity in children poses challenges. Therefore, dental radiographs play a crucial role in assessing such abnormalities. This retrospective analysis aimed to investigate trabecular patterns in the apical region of primary molars affected by unilateral and bilateral infraocclusion in Turkish individuals. The study utilized FA methodology and aimed to document any concurrent dental anomalies observed in panoramic radiographs.

Infraocclusion is strongly correlated with root resorption, a phenomenon often influenced by the eruption of premolar teeth and the shedding process of primary dentition, with possible variations depending on age. Peretz *et al.*[4] reported an increase in moderate infraocclusion rates between the ages of 8-10 and severe infraocclusion rates between the ages of 11-13. The study by Sidhu and Ali[19], noted that severe infraocclusion affected 2.5-8.3% of all infraoccluded primary molars. In our study, we observed a high prevalence of mild infraocclusion in primary second molars, which we attribute to the broad age range considered in our study.

In Kurol's study[20], based on clinical observations of 1059 children aged 3-12 years, it was found that infraocclusion was more prevalent in girls aged 3-6 years, while it was more common in boys aged 7-12 years. The incidence of infraocclusion of primary second molars was similar to the findings reported by previous studies; there was an insignificant difference in the prevalence of infraocclusion by gender.[21,22] However, Steigman *et al.*[23] discovered a higher incidence of ankylotic mandibular second primary molars among boys. Similarly, our study did not identify any statistically significant variation in infraocclusion occurrence based on gender.

According to Bjerklin and Bennett's classification, mild infraocclusion is the most frequently encountered category.[24] This observation is consistent with the findings reported by Brearley and McKibben[5], as well as Cardoso Silva *et al.*[22] In our study, employing the same classification method, primary molars were identified with mild (40%), severe (32%), and moderate (28%) degrees of infraocclusion, respectively.

Infraoccluded primary molars may lead to implications for the development and eruption of permanent teeth, potentially causing delays. Studies indicate that over half of the children with infraocclusion exhibit dental variations[25]. Dental anomalies accompanying this condition are often associated with hypodontia, dens invaginatus, and supernumerary teeth. Several studies have indicated a rise in dental anomalies linked to infraocclusion, including sub-occlusion of primary molars, palatally displaced canines, hypodontia, microdontia of maxillary lateral incisors, and distal angulation of mandibular second premolars.[26] Additional research has identified associated anomalies such as aplasia of permanent teeth, supernumerary teeth, radix entomolaris of permanent teeth, and a high prevalence of agenesis.[22,27] Several studies have noted increased infraocclusion in primary molars without successors.[28,29] In this study, hypodontia was the most prevalent accompanying anomaly, followed by microdontia and dens invaginatus in successor teeth (Figure 4, Table 5). In treatments such as dental implant placements and orthodontic interventions, it is valuable for clinicians to be aware of the bone quality in patients with infraocclusion.[30,31] It is noted that permanent tooth absence may lead to inadequate alveolar bone development.[32,33]

Infraocclusion treatment typically requires a multidisciplinary approach combining orthodontics, fixed and removable prosthetic treatments, and oral-maxillofacial surgery. This treatment involves varied approaches depending on the child's age and dentition stages.[34,35] Orthodontic treatment and dental implants are often considered to preserve bone structure in infraocclusion patients. However, it is generally advised to postpone these procedures until growth and development are complete, typically around ages 16-20.[36] Early placement of dental implants in children is primarily reserved for severe cases of tooth loss and is infrequently reported in the literature.[37,38] Additionally, in orthodontic treatment, it is emphasized that tooth movement may accelerate in cases of decreased bone density, and increased anchorage may be necessary in regions with low bone density.[39] In clinical practice, assessing the bone tissue condition in patients with infraocclusion is paramount. Fractal methods have been utilized to investigate the impact of systemic diseases on the jaw.[40,41] However, more studies need to conduct FD analysis specifically in individuals with infraocclusion.

This study examined individuals in the permanent and mixed dentition stages. Although it's usually recommended to wait until growth is complete before proceeding with dental implant procedures, analyzing the outcomes could offer valuable information about the trabecular bone structure in the mandible for patients receiving orthodontic treatment or dental implants. It has been noted that different methods should be used for analyzing the lower and upper jawbones. The box-counting method is the most commonly preferred method for calculations.[16] Therefore, this study only focused on deciduous teeth with infraocclusion in the mandible.

Panoramic or intraoral periapical radiographs and computed tomography (CT) are valuable tools for accurately measuring the distance between the surface of the infraoccluded tooth and adjacent teeth in cases of normal occlusion.[42] Most studies have evaluated FD in periapical, bitewing, and panoramic radiographs. For instance, Magat *et al.*[43], compared FA of trabecular bone between direct panoramic radiography and Cone Beam Computed Tomography (CBCT), stating that panoramic radiographs are more feasible and appropriate due to disadvantages such as higher radiation and lower image resolution associated with CBCT. Therefore, considering disadvantages like radiation dose, this study conducted analyses using direct panoramic radiographic images.

In FD analysis, the selection of ROI is influenced by parameters such as size, shape, and location of the region. It is noted that linear ROI usage is inadequate for evaluating trabecular structure, emphasizing the necessity of selecting planar ROIs.[44] In this study, planar ROIs were chosen. Since individuals were in mixed dentition and the study was conducted in a limited area, the size of selected ROIs varied according to the region.

Soltani *et al.*[45], conducted a cross-sectional study to examine trabecular bone alterations in periapical radiographs of individuals at various stages of periodontitis using FA. They found that FD values exhibited notable variations between moderate and severe periodontitis cases compared to individuals with healthy periodontal bone. However, it's worth noting that no significant difference in FD values was observed in the distal ROI for moderate and severe periodontitis cases. As it is known, periodontitis is a clinical condition with many influential factors. Bacterial and local etiological factors are very effective parameters in this regard. This study also showed that changes in the oral region, like these factors, impact the fractal distribution of the bone. Although our study had no statistical difference, the FD in infraoccluded teeth was lower than that of contralateral teeth. This shows that occlusal forces, although minor, have a positive effect on the FD.

A study examined the relationship between dental caries and mandibular trabecular bone using FD analysis during children's growth and development processes.[46] The results revealed no significant relationship between dental caries and trabecular bone in the jaw. This finding was similarly applicable to decayed infraoccluded teeth, reflecting a parallel situation to the results of our study.

A study on the impact of bruxism on the FD of mandibular trabecular bone using digital panoramic radiographs found lower FD values in the condyle regions of individuals with bruxism compared to those without.[47] Another study on 37 children with sleep bruxism reported significantly higher FD values in the angulus ($p = 0.03$) and condyle ($p = 0.03$) regions than controls.[48] It was also shown that ongoing occlusal forces in individuals with hyperactive masseter muscles alter the bone's fractal structure. Our study examined this effect on a single tooth but found no statistical difference, though infraocclusion may indicate a decrease in FD. Increased occlusal forces on all molar teeth, observed in studies on bruxism, contributed to the significant differences.

The limitations of this study are the small patient sample and the insufficient number of teeth examined. In future studies, the number of patients should be increased, and the condition of primary teeth in infraocclusion should be investigated. In addition, cases of primary teeth with infraocclusion can be categorized, and studies can be conducted covering both cortical and trabecular bone in the broader age range. A disadvantage of the study may be that it was retrospective and lacked quantitative measurements. There are also limitations in long-term follow-up or follow-up of patients with infraocclusion. Future research should focus on assessing changes in the severity of infraocclusion with age by including study groups spanning a broader age spectrum. To the best of the authors' knowledge, this study represents one of the most recent contributions and covers a limited number of topics covering all primary molars.

Conclusions

The research findings indicate that the quality of mandibular trabecular bone in the apical regions of individuals with infraocclusion did not significantly differ from that of the healthy group. However, patients presenting with such clinical characteristics require regular follow-up to monitor the severity of their condition, and treatment should be administered accordingly. Consequently, individuals with infraocclusion in primary teeth may necessitate additional procedures to facilitate further treatment in orthodontic and implant cases. Moreover, mandibular bone density plays a crucial role in procedures such as grafting and tooth movement, highlighting the importance of assessing and managing bone quality in such cases.

Acknowledgements

None.

Conflict of Interest

The Authors declare that there is no conflict of interest.

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Cumhuriyet Dental Journal, 27(2): 136-141, 2024
DOI: https://doi.org/10.7126/cumudj.1394372

Cumhuriyet Dental Journal

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

Rootless Tooth Hanging with Gutta Percha Cone: Report of a Case with Replacement Root Resorption

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Case Report

History

Received: 22/11/2023
Accepted: 19/02/2024

ABSTRACT

Resorption results in damage of tissues by either physiologic or pathologic process. External root resorption begins with the cementum, dentin or both and continues inwards approaching the pulp of the tooth. It may penetrate the pulp if not treated, leading to a connection between the pulp tissue and the bone. Replacement root resorption is type of resorption distinguished by loss of tooth substance along with periodontal ligament (PDL) and its replacement by bone tissues resulting in dental ankylosis. External replacement resorption is progressive in nature. Age has a strong impact on the rate of resorption, thus young individual experiences faster resorption. Clinical and radiographic features of mobile maxillary anterior tooth in an 18-years-old male have been described in the present report. Clinical examination revealed pinkish discoloration, mobility and intrusion with the maxillary left central incisor (#21) and Ellis class II fracture in the maxillary right central incisor (#11). Intra oral periapical radiograph revealed complete root resorption with 21 and radiopaque root canal restorative material in the alveolar region giving unique radiographic presentation of hanging crown with the support of gutta percha cone. Cone beam computed tomography after the tooth extraction reveled retained endodontic material in the alveolar bone. In cases of trauma to the tooth leading to avulsion and reimplantation of the tooth, dental practitioners should be aware of prognosis in terms of external replacement root resorption. The present article aims to report the unique presentation of external replacement resorption and highlight the importance of regular long term follow up.

Keywords : Root Resorption, Dental Trauma, Replacement Resorption

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How to Cite: Tannishtha, Hegde S, Babu GS, Ajila V. (2024) Rootless Tooth Hanging with Gutta Percha Cone: Report of a case with Replacement Root Resorption, Cumhuriyet Dental Journal, 27(2): 136-141.

Introduction

Resorption results in loss of tissue substance from physiological or pathological process. Loss of dentine, cementum occurs in tooth resorption. Replacement root resorption is type of resorption distinguished by loss of tooth substance along with periodontal ligament (PDL) and its replacement by bone tissues resulting in dental ankylosis. Osteoclastic activity results in resorption of the tooth and osteoblastic activity generates new bone.[1] Dental trauma causes irreparable injury to PDL. External replacement resorption generally occurs after an injury to the PDL and/or external root surface, leading to necrosis in the PDL cells and subsequent ankylosis. As the predominant healing response takes on an osseous nature, the tooth loses the protection provided by the PDL. This loss allows clastic cells from the nearby bone to initiate the resorption of cementum and dentin. Osteoblasts then generate bone in the resorption area. This progressive process ultimately results in the complete resorption of the root and the subsequent loss of the tooth.[2] Age has a strong influence on replacement resorption; rate of resorption is faster in younger patient. External root resorption is more prevalent among individuals aged 21 to 30 years, with a higher incidence in females compared to males.[3] In a study assessing the frequency of root resorption in cases of dental trauma involving supporting tissues, it was observed that 77.4% of the cases exhibited external inflammatory root resorption, while replacement resorption was uncommon, occurring in only 4.8% of the cases.[4] If ankylosis, occurs before the age of ten or before the individual's development peak, there is a significant probability of infraocclusion. However, in individuals aged above twenty, slower rate of resorption of root was reported. The associated tooth/teeth with no clinical symptoms, no movement, produces metallic sound in reaction to percussion.[5,6] Loss of lamina dura and PDL evident in the radiographs in case of ankylosis. Resorption with replacement is an irreversible process and presently no preventive methods are available.[7] The sole treatment is to avoid damage to the PDL following trauma.[8] Present case shows unique features of external replacement resorption with pinkish discoloration, mobility, complete loss of the root structure and crown hanging with restorative material 10 years after trauma to the tooth.

Case Report

A male of age 18 years presented with a mobile tooth in his maxillary anterior region for one month. Past history revealed avulsion of the same tooth secondary to trauma which was repositioned and root canal treated 10 years back. On intra-

oral examination, pinkish discoloration, mobility and intrusion was observed with maxillary left central incisor (#21). Ellis class II fracture was seen in the maxillary right central incisor (#11), as shown in Figure 1. The provisional diagnosis of internal resorption for #21 was made. Intra-oral periapical radiograph revealed complete root resorption with #21 and radiopaque root canal filling material in the alveolar region, depicting as rootless tooth hanging with gutta-percha cone (Figure 2). Fracture of enamel, dentine, and external root resorption were noticed with respect to #11. The clinical and radiographic features of #21 led to the final diagnosis of replacement root resorption. The patient was advised for extraction of #21 and prosthodontic rehabilitation. After the extraction patient was advised to undergo cone beam computed tomography (CBCT) imaging for further management. CBCT revealed buccally present endodontic restorative material in the alveolar bone with respect to 21 region and bone defect was observed with respect to 21 and 22 regions. Root resorption was also noticed with 11 and 22. The root resorption observed with tooth 11 resembled external apical inflammatory root resorption, while that with tooth 21 resembled external replacement resorption (Figure 3-5). Implant therapy was planned for the missing 21.

Figure 1: Clinical image showing pink tooth of mummery with respect to left maxillary central incisor.

Figure 2: Intra-oral periapical radiograph showing severe replacement resorption and complete loss of root structure and radiopaque restorative material suggestive of endodontic treatment with #21 and fracture of enamel and dentine along with external root resorption with #11 .

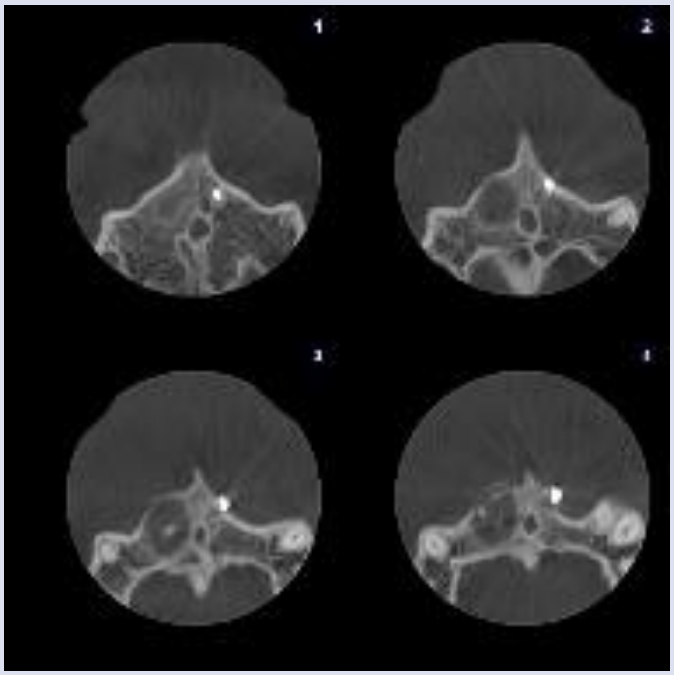

Figure 3: Cone beam computed tomography (CBCT) Axial sections showing the position of the residual endodontic material and the bone defect.

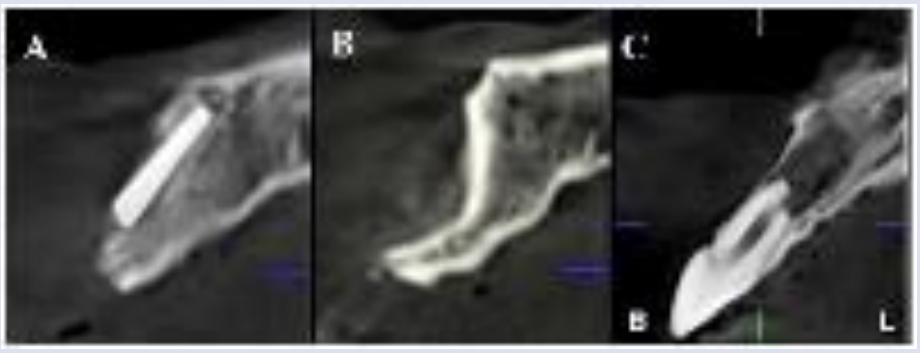

Figure 4: Cross sections in CBCT (A and B) showing buccally placed residual endodontic material with bony defect seen on the buccal aspect of 11 region. C) Root resorption resembling external apical inflammatory resorption seen in 11 with periapical pathology.

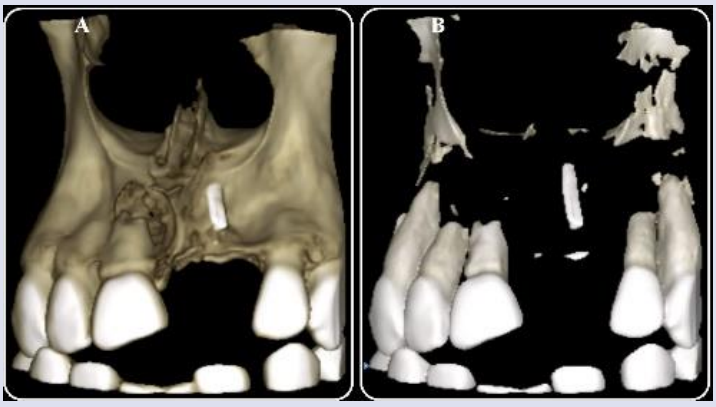

Figure 5: A) 3D reconstruction showing radiopaque material in the 21 region, B) Skimmed 3D reconstruction

Discussion

Resorption can lead to the depletion of surrounding bone, dentin, and/or cementum of the tooth. Root resorption can be classified into internal root resorption and external root resorption.[9,10]

Internal root resorption originates inside the root canal walls pulp or dentin. It extends outward towards the cementum and, in its final stage, may interact with the surrounding bone and PDL if left untreated. It can be further classified into resorption of surface, resorption of inflammatory origin and replacement resorption.

Whereas, external root resorption starts inside cementum, dentin or both If the cementum is not present at the site of initiation of resorption and moves inwardly towards the tooth pulp. It may reach pulp and cause interaction between the pulp and adjacent bone if untreated. It can be classified into surface resorption, inflammatory resorption, replacement resorption, invasive resorption, pressure resorption, orthodontic resorption, physiological resorption, idiopathic resorption.[2]

The present case report discusses external replacement root resorption, where cementum and dentin were resorbed and replaced by surrounding bone. PRICE 2020 Flow chart shows progress of present case (Figure 6). External replacement resorption is most commonly seen after trauma to the PDL and/or the outside root surface (cementum).[11-13] It occurs frequently with major luxation injuries such as avulsion and intrusion. Additionally, in the apical region, when the root rubs against the bony ledge created by the labial alveolar cortical plate fracturing, it may occur after lateral luxation. It may also occur on the palatal area on the root of coronal third, when the PDL and cementum are crushed due to bone contact with the alveolar socket wall. It is less likely to arise after extrusion because the root surface is less damaged. Nonetheless, because of the damage to the PDL, external replacement resorption remains a possibility.[9] Pathogenesis of external replacement resorption depicted in figure 7.[2]

External replacement resorption can be divided as (a) external transient replacement resorption and (b) external progressive replacement resorption. External transient replacement resorption occurs with minor damage to a limited portion of the root and PDL. At times, fibroblasts within the neighboring PDL contribute to the healing process of the PDL itself. In external progressive replacement resorption entire root will be resorbed followed by loss of tooth.[2]

On clinical examination, teeth exhibiting external replacement resorption will be less mobile, accompanied by a distinct percussive sound and sensation. The sound has been characterized as "high-pitched," "metallic," or "woody" by many authors, although it varies depending on the level of resorption. In most cases, the patient reports no symptoms and frequently has a history of a severe tooth damage or trauma. In more severe instances, the tooth may appear submerged, especially if the resorption started before puberty.[14,15]

On radiographic examination there will be regions where the outermost tooth material is resorbed and substituted by surrounding bone. Because certain areas may have faster resorption than others, the remaining root may have a very uneven appearance. In regions where resorption has taken place, The PDL space is expected to disappear, with the loss of the lamina dura.[16]

External transient replacement resorption doesn't need intervention, but the tooth must be checked on a regular basis before coming to a final diagnosis.[2]

The treatment of external progressive replacement resorption involves routinely taking periapical radiographs and clinical evaluation of the tooth to assess the resorption rate and the patient should be mentally prepared for tooth loss ultimately. Furthermore, due to cosmetic difficulties involved, the location should be taken into consideration and a future prosthetic tooth replacement, particularly if anterior tooth is involved. In our case, patient had to undergo extraction of remaining portion of the tooth which was discolored and mobile. Patients' age and dental growth stage should be considered, as the tooth undergoing resorption will not erupt in the future. This can negatively impact alveolar bone growth, leading to a bone defect that may be challenging to manage. In some cases, decoronation just beneath the crestal bone and "root burial" may be appropriate procedures to preserve bone in the area during tooth resorption and promote normal alveolar bone development.[15]

When possible, the ideal course of action is to prevent external replacement resorption; however, this is not always achievable since root and PDL damage usually develops before a patient who has had dental trauma visits a dental surgeon. Even if a dentist is consulted after an accident, like an avulsion, it can be too late for them to provide an advice on managing the tooth's first aid. One of the most crucial preventative strategies is to shorten the avulsed teeth's extra-oral time period. If the tooth cannot be transplanted, the use of an appropriate storage media should be encouraged, which will avoid the additional harm to PDL and root during the process of replantation or repositioning of the tooth, use of a splint (functional), preventing root canal treatment been done extra orally and delaying the use of $Ca(OH)_2$ which is a root canal medicament will be of great importance.[11,17] Primary drawback of the present study is reliance on the patient-provided information for evaluating the history of trauma, its type, and the treatment process.

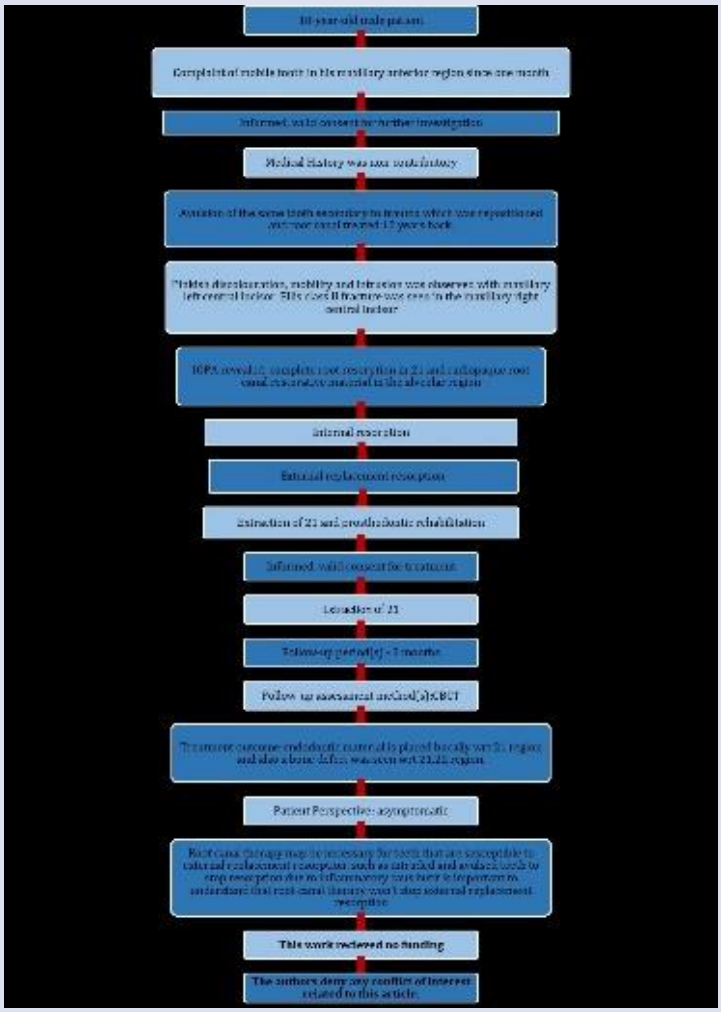

Figure 6: PRICE 2020 Flowchart.

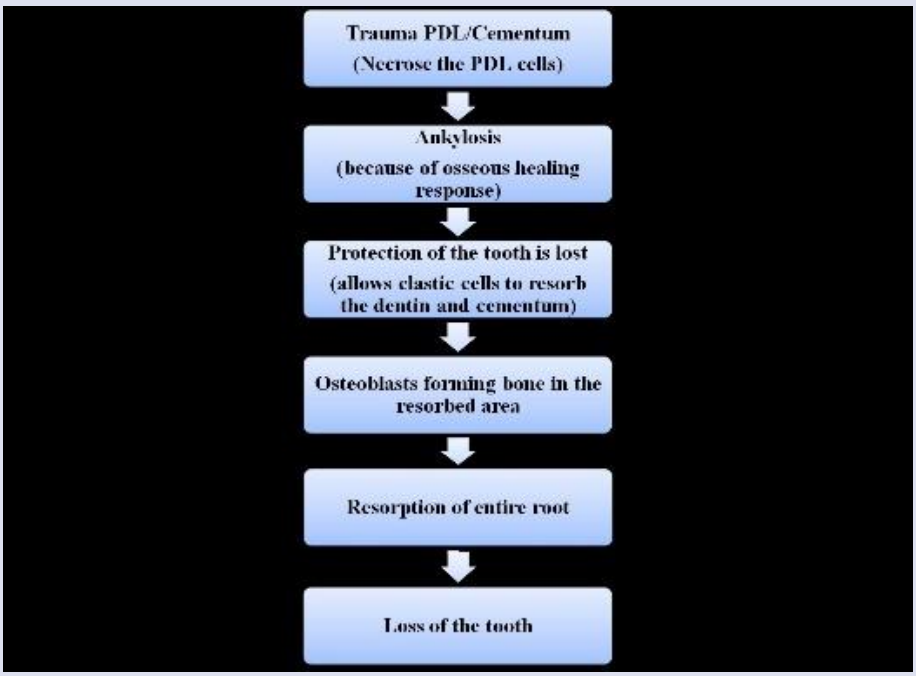

Figure 7: Mechanism of external replacement resorption .

Conclusions

In cases of trauma to the tooth leading to avulsion and reimplantation of the tooth, dental practitioners should be aware of prognosis in terms of external replacement root resorption. The present report highlights the unique presentation of external replacement resorption and emphasizes the importance of regular long term follow up.

Conflict of Interest

The authors declare that they have no conflict of interest in relation to this article

Source of Funding

This research did not receive any specific funding.

Informed consent

Informed consent was taken from the patient to publish.

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Cumhuriyet Dental Journal, 27(2): 142-146, 2024
DOI: https://doi.org/10.7126/cumudj.1412357

Cumhuriyet Dental Journal

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

Non–Syndromic Impacted Primary Molar with Eruption Disturbance in Premolars: A Case Report of an Unusual Occurrence

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Case Report

History

Received: 30/12/2023
Accepted: 21/05/2024

ABSTRACT

Tooth impaction is a commonly observed dental anomaly frequently discussed in the dental literature. Overall, the prevalence of impacted teeth in deciduous dentition ranges between 1.3% to 8.9%, with siblings experiencing a noticeably greater incidence. Based on the data, the most impacted primary teeth seen in children are second deciduous molars, followed by primary central incisors. Impaction of primary teeth may be associated with disturbance in their permanent successors, so long-term observation is necessary until the permanent successors erupt. Therefore, the present case report aims to describe a rare and unusual eruption disturbance of premolars in a pediatric patient caused by impaction of the primary molar.

Keywords : Ankylosis, Eruption Failure, Impaction, Primary Molar, Transposition

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How to Cite: Sultan A, Juneja A, Zaman M. (2024) Non–Syndromic Impacted Primary Molar with Eruption Disturbance in Premolars: A Case Report of an Unusual Occurrence, Cumhuriyet Dental Journal, 27(2): 142-146.

Introduction

Tooth impaction is a commonly observed dental anomaly frequently discussed in the dental literature.[1] A tooth is considered "impacted" when it remains unerupted more than one year after the usual age for its eruption.[2] The occurrence of impacted permanent teeth varies according to the population and ranges between 6.9 and 76.6%.[1] The most frequently impacted teeth are the third molars(16.7% to 68.6%)[3] , followed by maxillary canines(0.8 – 3.6%) [1]and premolars.[1,3] It has been documented that the incidence of impacted premolars varies with age. According to reports, the prevalence in adults is 0.5%; the range for maxillary premolars is between 0.1-0.3%, and mandibular premolars is between 0.2-0.3%.[4,5]Also, the impaction of maxillary premolars and canines is seen more often palatal, while the incidence of mandibular premolars impaction is predominantly lingual.[6] Overall, the prevalence of impacted teeth in deciduous dentition ranges between 1.3% to 8.9%, with siblings experiencing a noticeably greater incidence.[7,8] Based on the data, the most impacted primary teeth seen in children are second deciduous molars, followed by primary central incisors.[9] Also, primary mandibular molars tend to be impacted more than ten times as frequently as primary maxillary molars. Further, total impaction, on the contrary, is a highly uncommon phenomenon, and only a few cases have been documented in the literature.[8]

The impaction can be categorised as either primary, when the tooth has not yet erupted (also known as the primary failure of eruption) or secondary, meaning the tooth becomes re-impacted after eruption following various reasons.[10,11] Primary failure of eruption is confirmed if the mucosa around the unerupted tooth is firm and radiographically, the tooth appears to be deeply embedded in the jaw bone.[11] When the permanent tooth fails to erupt because of a retained primary tooth, an odontoma, a cystic lesion, or an extra tooth, this is diagnosed as a secondary failure of eruption.[8]

An impacted tooth is usually associated with several systemic prenatal and postnatal disorders, diseases, and syndromes. Various factors can lead to impaction of a deciduous tooth, including trauma, malposition, dilacerations, ankylosis, injuries of the periodontal ligament, congenitally missing permanent teeth[8,11-14] local disturbances in the periodontal membrane of the RANK (receptor activator of nuclear factor kappa-B) / RANKL (RANK ligand)/OPG (osteoprotegerin) system[15], premature eruption of the first permanent molar, inadequate eruptive forces, cleidocranial dysostosis and hypopituitarism[8] or a combination of these factors. In certain situations, environmental or familial factors may also be involved.[15] Unerupted deciduous molars can result in a couple of complications in the oral cavity

including space loss in the dental arches, tipping of adjoining teeth and supra eruption of the antagonist. Further, the unerupted primary molars also affect the development of the corresponding premolars and may prevent their movement to their functional position in the oral cavity.[10,14,15]

Whenever an impacted tooth is suspected, a thorough radiographic evaluation of the region should be performed, along with a clinical examination. Usually, an Orthopantomagram (OPG) along with an occlusal radiograph is essential. However, full three-dimensional (3D) details of all the components in the oral cavity cannot be seen clearly in these radiographs, mainly due to the overlapping anatomical structures.[16] The palatally impacted premolars may not always be seen on a standard Intra oral periapical (IOPA) radiograph because they are occasionally located horizontally relatively high in the palatal vault close to the nasal and sinus floor.[4] Therefore, a precise and correct diagnosis is vital for proper treatment. Cone-beam computed tomography (CBCT) is beneficial in locating the impacted teeth precisely and is often utilized as an alternative or along with conventional techniques.[17]

In comparison to permanent teeth, impaction and eruption failure in primary teeth are uncommon, and very few cases have been reported in the dental literature.[7,14]

This report presents a case of an impacted primary maxillary first molar, including bilateral impaction of maxillary premolars in a nine-year-old girl. This paper also highlights the significance of proper and timely diagnosis and treatment planning to avoid undesirable complications following the impaction of teeth.

Case Report

A nine-year-old girl, was referred to the Out Patient Department (OPD) of the Department of Paediatric & Preventive Dentistry of the dental college with the chief complaint of pain in 64. On intra-oral examination, the patient's occlusion was in the mixed dentition stage, with carious maxillary left first primary molar. Also, both the right maxillary molars (54 & 55) were clinically missing resulting in mesial tipping of the crown of the maxillary right first permanent molar. There was no evidence of soft tissue swelling or discolouration of the surrounding dentition. (Figure 1) The panoramic radiograph established the impaction of 54, along with 14, and 15, and also confirmed the congenital absence of 55 and 45. The radiograph displayed the distoangular impaction of 14 which was positioned mesial and slightly above the level of 54, while 15 was vertically impacted, and appeared to be placed distal to 54. No significant resorption was evident in the roots of impacted right primary maxillary molar. Impacted 14 and 15 showed developing roots. There was absence of any circumscribed radiolucency around the impacted premolars. The radiograph further revealed horizontally angulated 24 and transposition of 23. (Figure 2) A CBCT scan was advised for the precise diagnosis. The 3D images of the maxilla and mandible corroborated impaction of 14, which appeared to be near the nasal floor, impaction of 15, superiorly positioned 23 in the alveolus in buccal relation to 64, mesioangular impaction of 24 in close approximation to the palatal cortex. The images also showed the rotation of 25 on its axis. (Figure 3) Any anomalous growth/calcium deposits were also not seen. The patient did not reveal signs and symptoms of any syndrome and gave no history of infection or dental trauma. Clinical examination of parents did not reveal any genetic predisposition to the condition.

The patient's chief complaint (proximal caries) was managed and the carious left maxillary primary first molar was restored with Glass Ionomer Cement. We will follow a multidisciplinary approach to manage the dental implications. The space observed in the dental arch was insufficient for the eruption of impacted maxillary primary molar. Space regaining followed by surgical extraction of 54 and extrusion of 14 and 15 has been planned in collaboration with the Orthodontic and Oral Surgery department. At present, restorative and space regaining procedure has started.

Figure 1: Intraoral picture of maxillary and mandibular arch.

Figure 2: OPG showing impacted 54, 14,15, transposition of 23, mesioangular impaction of 24 and missing 45.

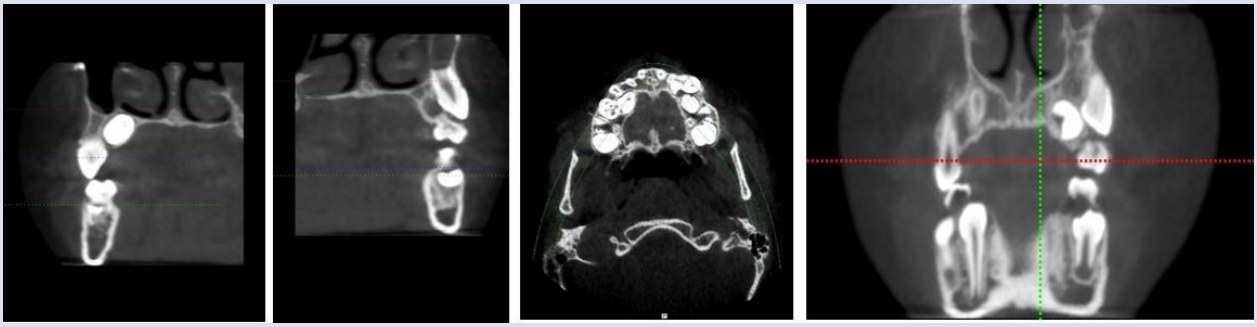

Figure 3: CBCT images showing impacted teeth.

Discussion

An impacted tooth refers to one that is either locked in place by bone or the tooth(s) or fibrous tissue next to it; or one that has become stuck in the alveolus that obstructs its normal functional eruption.[18] In our patient, the most significant observation was the impaction of the right maxillary primary first molar, while the contralateral maxillary primary molar was clinically present. Also the right maxillary second molar was congenitally missing. Only 2.5% to 8.3% of children have been reported to have primary molar impaction. These observations are comparatively uncommon.[19]

In our patient, there was no applicable familial or health history. The factors responsible for primary tooth impaction can be systemic and local. The local aetiology of an impacted primary tooth can be divided into two groups.[20] One is the impacted primary tooth itself,[10] whereas other causes include mechanical blocking due to deformity in tooth germ, shift in tooth position, traumatic injury, ankylosis, gingival hyperplasia, and lack of space for tooth eruption[14] along with certain dental anomalies like eruption cyst, odontogenic tumours and odontomas.[14,20]

Most documented reports of impacted primary teeth in the literature have been shown to result from odontomas.[14,19] Besides there have been reports of an impacted primary tooth with an unknown cause.[14]

The cause of impacted 54 in this case could be malpositioned tooth germ of premolar there is evidence in literature when a permanent successor had interfered with the eruption of a primary molar into a normal occlusion.[21,22]

Based on the embryological findings, the tooth buds of premolars develop in the palatal area of the maxillary arch and in the lingual part of the mandibular arch in relation to the enamel organ of the deciduous dentition. Normally, the tooth buds of premolars are positioned near the occlusal surface of the primary molars, which change their position moving toward the roots of the primary molars.[15,19] In the present case the maxillary right first premolar (14) may have developed in a superior and lateral position with respected crown of the impacted maxillary right primary first molar (54). And this phenomenon leading to the non-eruption of primary molar usually occurs before the age of three years when the permanent tooth bud in the initial stage is located

laterally to the arrested primary molar as reported by Kjaer *et al*.[15]

The impacted primary molar in this case did not show ankylosis. Some previous reports have suggested ankyloses can lead to an impacted primary molar, and anticipated that an ankylosed unerupted deciduous molar will become more deeply embedded in the alveolar bone during growth of the jaws. Also, the analysis of the characteristics of the impactions in primary teeth in the literature, suggests that ankylosis is probably a leading role in etiopathogenesis of impaction.[14,23-25]

Impaction of primary teeth may be associated with disturbance in their permanent successors, so long-term observation is needed until the permanent successors erupt.[19] Even though the impacted teeth are asymptomatic, some can result in issues such as pain, infection, cysts, tumours, resorption of the adjacent tooth and marginal bone close to the impacted teeth, jaw fractures and mal-positioning of the mandibular incisors.[1,2] Impacted teeth are often associated with pericoronitis, periodontitis, cystic lesions, neoplasm, root resorption and can cause detrimental effects on the adjacent tooth.[26] Due to impacted primary molars, the premolars can be positioned abnormally in the jaw bones. However, the reason for this is not yet clearly understood. It is presumed that if there is no abnormality, the premolar reaches the furcation area of the primary molar, however, they may not move and develop near/on the occlusal plane of the primary molar for whatever reason.[21,22]

In our case there was also radiographic evidence of horizontally angulated 24 and transposition of 23. The incidence of maxillary canine-premolar transposition is reported to be 0.135-0.510% and is genetically influenced. Majority of maxillary transpositions are unilateral with a higher involvement seen on the left side. Most transpositions are of canine–lateral incisor and are associated with other dental anomalies.[25]

Treatment options can be considered in cases where impacted premolars have enough space to erupt, like periodic observation; extraction of the primary tooth and monitoring of the permanent tooth; surgical exposure and exteriorization, with or without orthodontic traction; surgical repositioning (auto-transplantation) etc. In other cases, surgical extraction of impacted premolar can be considered. In some cases, spontaneous eruption of impacted tooth might occur after surgical exposure, however, orthodontic alignment may be required.[5,27]

Impaction of primary teeth might be seen infrequently but can result in several complications. Paediatric dentists should be aware of these complications and diagnose these clinical abnormalities accurately. Also, by timely addressing them, they should prevent any disruptions to the eruption pattern in the permanent dentition.

Conclusions

The diagnosis, planning, and treatment of impacted primary teeth must consider the clinical consequences since failure to do so could result in the displacement of the succeeding permanent tooth, which might interfere with the growth of the permanent dental arch.

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