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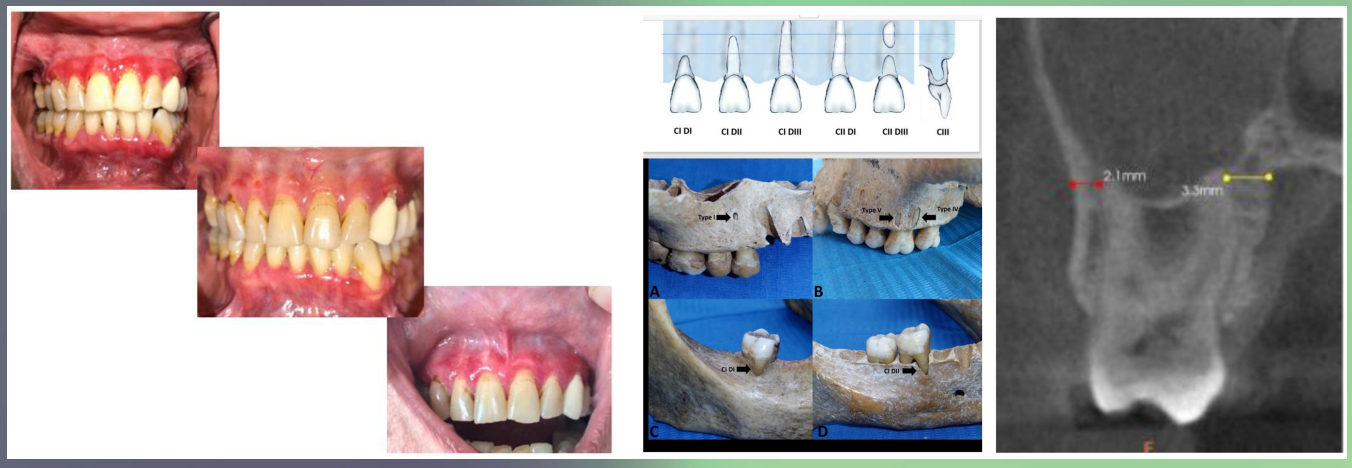

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Current Research *in* Dental Sciences

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Current Research in Dental Sciences

Research Article *Araştırma Makalesi*

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Fenestration and Dehiscence Types in Turkish Subpopulation Skulls

Türk Alt Popülasyonuna Ait Kuru Kafalardaki Fenestrasyon ve Dehisens Tipleri

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ABSTRACT

Objective: The objective of the study is to evaluate the fenestration and dehiscence types in Turkish human skulls according to 2 classifications.

Methods: For the study, 297 skulls with 1808 teeth were analyzed from a collection of anatomy laboratories of 2 universities. Yang's and Pan's classifications were used to determine fenestration and dehiscence types. Chi-square and Fisher's exact tests were used for statistical analysis.

Results: There was no statistical difference in the presence of fenestration and dehiscence between the maxilla and mandible ($P > .05$). Type IV was most common fenestration in the maxilla ($P = .029$). Types III and IV were the most common types in the mandible ($P < .05$). CI DI and CI DII were the most common dehiscence in the maxilla and mandible, respectively ($P < .05$). The maxillary first premolar showed the highest prevalence of fenestration ($P < .001$). The mesial root of the maxillary first molar showed the highest prevalence of dehiscence ($P < .05$).

Conclusion: The prevalence of fenestration and dehiscence was 8.70% and 10.06%, respectively, in Turkish human skulls. Fenestration in maxilla were mostly located in middle and apical of the root (type IV), the ones in mandible were in the coronal third of the root (type III). The most affected tooth was the maxillary first premolar for fenestration and the maxillary first molar for dehiscence. Most dehiscences in the maxilla were located in the coronal (CI DI), and they were located in both the coronal and middle thirds (CI DII) in the mandible.

Keywords: Alveolar bone, dehiscence, dry skull, endodontics, fenestration, mucogingival surgery

ÖZ

Amaç: Çalışmanın amacı Türk insan kuru kafataslarındaki dehisens ve fenestrasyon tiplerini iki sınıflamaya göre değerlendirmektir.

Yöntemler: Çalışma için iki üniversitenin anatomi laboratuvarlarının koleksiyonundan 1808 dişe sahip 297 kafatası analiz edildi. Fenestrasyon ve açılma tiplerinin belirlenmesinde Yang ve Pan'ın sınıflandırmaları kullanıldı. İstatistiksel analizde ki-kare ve Fisher exact testleri kullanıldı.

Bulgular: Maksilla ve mandibula arasında fenestrasyon ve dehisens varlığı açısından istatistiksel fark bulunamadı (P>.05). Maksillada en sık görülen fenestrasyon Tip IV idi (P=.029). Alt çenede en sık görülen tip III ve IV tipi idi (P<.05). CI DI ve CI DII sırasıyla maksilla ve mandibulada en sık görülen dehisens tipleriydi (P<.05). Üst birinci küçük azı dişi en yüksek fenestrasyon prevalansını gösterdi (P<.001). En yüksek dehisens prevalansı ise maksiller birinci moların mezial kökünde görüldü (P<.05).

Sonuç: Türk insan kafataslarında fenestrasyon ve dehisens prevalansı sırasıyla %8.70 ve %10.06 idi. Maksilladaki fenestrasyonların çoğu kökün hem orta hem de apikal üçlüsünde konumlanan tip IV sınıfına aitti. Mandibuladaki fenestrasyonlar ise koronal üçlüde (tip III) yerleşmişti. En çok etkilenen diş grupları; fenestrasyon için üst birinci premolar, ve dehisens için üst birinci molardı. Maksilladaki dehisensin çoğu koronal bölgede (CI DI) konumlanırken, mandibuladakileri çoğu ise hem koronal hem de orta üçlüyü içeren CI DII sınıfına aitti.

Anahtar Kelimeler: Alveolar kemik, dehisens, kuru kafatası, endodonti, fenestrasyon, mukogingival cerrahi

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INTRODUCTION

"Gomphosis," a unique type of fibrous joint, exists between the teeth and the alveolar bone that supports the root in the presence of masticatory forces.[1] The interaction between the physiology of teeth and alveolar bone is bidirectional, with advanced bone loss causing tooth mobility and missing; similarly, the nonexistence of the tooth also leads to the resorption of the alveolar bone.[2] The deficiencies in the alveolar bone and the structure of the "gomphosis" joint, which is termed fenestration or dehiscence, concern all disciplines of dentistry.[3] These defects have importance in the prognosis of periodontal surgery, implant placement, orthodontic treatment planning, the spread of an endodontic infection, or the processes of endodontic treatment, including the extrusion of irrigation solution or medicaments. Fenestration and dehiscence are the bone defects that characterize the absence of alveolar bone and the exposed root surface, and since they are generally asymptomatic and detected by periodontists during mucogingival surgery, clinical detection requires the utmost attention.[4] American Association of Endodontists described fenestration as a window-shaped defect with an intact bridge-like bone on the coronal part of the root, while dehiscence has no bridge-like bone with a total interruption of bone and a denuded root surface.[5] Etiological factors of these bone defects are various, including topography or dimensions of the root and its location on alveolar bone, periodontal or endodontic infection, trauma, high frenum attachment, abnormal occlusal forces in strength or direction, improper orthodontic forces, and in addition to these, an insufficient alveolar bone thickness that leads to malnourishment predisposes to fenestration and dehiscence.[4-6]

In different populations, many studies investigated fenestration and dehiscence using dry skulls[3,6-14] or cone-beam computed tomography (CBCT).[4,15-17] These studies reported the distribution or prevalence according to the tooth groups or different skeletal patterns. However, the detection of the presence is not sufficient from the clinical perspective. The width or height of the denuded root surface, the located root third, the involvement of apical foramen, and the coexistence of dehiscence and fenestration should be determined to estimate the prognosis or to decide the treatment. To determine the different properties of bone defects, 2 types of classifications of Yang et al[15] and Pan et al[4] were described in the literature. Yang et al[15] defined the dehiscence type as follows: CI DI, which is on the coronal third; CI DII, which is on the coronal and middle thirds; CI DIII, which is on the whole root; CII DI, which is located on the total root surface with the involvement of apical foramen; CII DII, which includes a periapical lesion; CII DIII, which is the coexistence of dehiscence and fenestration; and CIII, which is located on buccal and lingual aspects. Pan et al[4] classified the fenestration types as follows: type I, II, and III which are positioned on the apical, middle, and coronal thirds, respectively, and type IV which is placed on the apical and middle together, type V, on the middle and coronal together, and type IV, which is extended to whole root surface excluded of bone margin. There are limited data about the analysis of different patterns of fenestration and dehiscence; the literature was generally focused on the presence of defects.

Lately, according to these classifications, bone defects were investigated using CBCT.[4,15,17] Unfortunately, it is noted that CBCT has a major limitation in that it cannot detect the presence of bone and assumes a defect area in the case of bone thickness below the voxel size of the device.[18] There is no study in the literature that investigates the types of fenestration and dehiscence using a dry skull or mandible directly. Therefore, we aimed to analyze the distribution of fenestration and dehiscence types with direct observation using a dry skull maxilla and mandible. The null hypothesis of our study was that no difference would be detected between types of fenestration or dehiscence.

MATERIAL AND METHODS

Three hundred fifty-eight (358) dry adult human skulls of Turkish origin were selected from the anatomy department laboratory of Süleyman Demirel University, Faculty of Medicine, and Akdeniz University, Faculty of Medicine, with the obtained allowance. The age and gender of the skulls were unknown. Inclusion criteria were the preserved skulls, the presence of at least 1 tooth, intact alveolar bone, and no signs of dental infection as a visible bone defect in the periodontal area, alveolar bone, or the apical region of the tooth. In addition to these, teeth with completed eruption and without advanced occlusal wear or excessive caries and dry maxilla or mandible without certain postmortem damage such as cracks or fractures were included. Exclusion criteria were deformed, fragmented, or ragged alveolar bone, postmortem damage, edentate jaws, misaligned teeth, and teeth without structural integrity. Two observers of this study (D.Y., a 6-year experienced endodontist, and A.M.N., a 10-year experienced periodontist) performed the selection of skulls according to the inclusion or exclusion criteria. To exclude periodontal loss, the interproximal bone loss of each specimen was analyzed. The teeth were evaluated individually in terms of interproximal bone height rather than the general status of the teeth in the skull. The teeth with interproximal bone loss >2 mm were not included. After the inclusion and exclusion criterion, 297 skulls (133 mandibles and 164 maxillae) were selected. The samples selected were those that both observers agreed to include according to the inclusion criteria. For the study, 1808 teeth in the 297 skulls were examined.

The presence of fenestration and dehiscence according to the classifications was recorded with a direct visual examination. To define the fenestration, the presence of a bridge-like bone structure was confirmed, and the types were recorded according to Pan et al.[4] The absence of bone at least 4 mm apical to the interproximal bone[8] was defined as dehiscence and classified according to Yang et al[15] in terms of its position at the root (Figure 1). For each individual specimen that contains dehiscence, the depth of bone defect was measured with a periodontal probe (PCP UNC 15, Hu-Friedy, Frankfurt, Germany) to confirm 4 mm of bone loss.

The data analysis was performed by 2 observers (a 10-year experienced periodontist and a 5-year experienced endodontist), independently, in accordance with the classifications. Before saving the data, the observers were calibrated with the evaluation of 10% of the teeth (180 teeth); subsequently, kappa scores were stated (ranging from 0.93 to 0.94). After the calibration, the bone defect type in each individual tooth was recorded on a study chart. All specimens were examined by 2 observers independently.

Statistical analysis was performed using Statistical Package for the Social Sciences Statistics version 22.0 software for Windows (IBM Corp., Armonk, NY, USA). To compare the types of fenestration and dehiscence in the maxilla and mandible, the chi-square

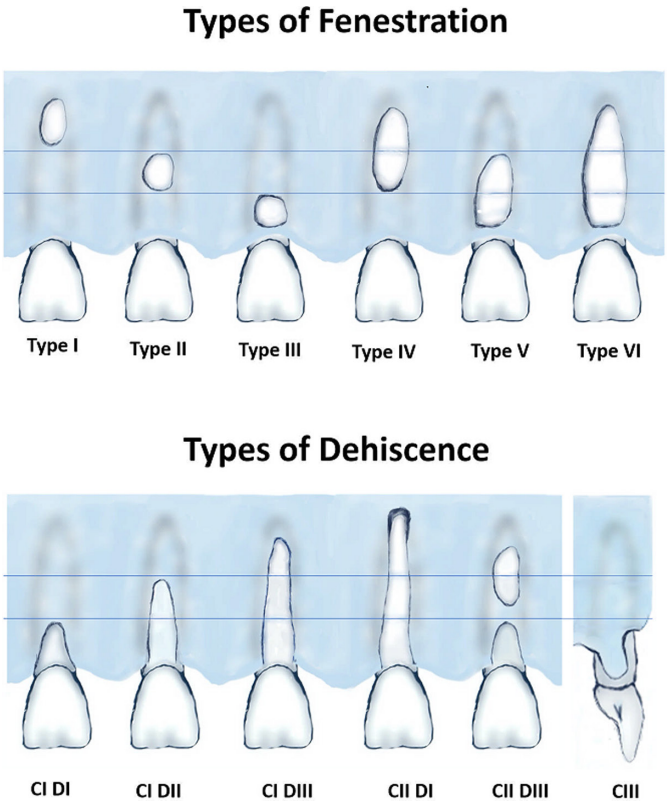

Figure 1. Types of fenestration and dehiscence.

test and, if necessary Fischer exact test, was performed. To evaluate the interobserver reliability, the Cohen's kappa test was used. The level of statistical significance was set at $P < .05$ with a 95 % CI.

RESULTS

A total of 1808 teeth were examined in 297 skulls. There was no significant difference between the maxilla and mandible in the presence of fenestration ($P = .64$) and dehiscence ($P = .12$). All fenestrations were located in the buccal aspect; there was no fenestration in the lingual aspect of the root, while 0.27% of dehiscence was located on both sides.

In terms of the distribution of the fenestration, in the maxilla, the highest rate (28.23%) was in the first premolar ($P < .001$). The lowest rate (4.65%) was in the distal root of the second molar. In the mandible, the highest (16.66%) rate was in the canine ($P = .042$). The lowest (5.58%) rates were in the distal roots of the first and second molars equally (Table 1).

Table 2 shows the distribution of the fenestration types according to the classification of Pan et al.[4] In the maxilla, the most common type of fenestration was type IV (27.05%) ($P = .029$). The rarest type was type VI (8.13%). In the maxilla, there was no statistical difference between type I (24.41%) and type II (24.41%) ($P > .05$). However, type I (24.41%), type II (24.41%), and type IV (27.05%) were statistically higher compared to type III (9.30%), type V (5.81%), and type VI (8.13%) ($P < .001$).

In the mandible, the most observed types of fenestration were type III (38.88%) and type IV (31.94%). Type VI of fenestration was not detected (Figure 2). There was no statistical difference between type III (38.88%) and type IV (31.94%) ($P > .05$). Type III (38.88%) and type IV (31.94%) were statistically higher than type I (5.55%), type II (11.11%), and type V (12.50%) ($P < .05$).

In terms of dehiscence, in the maxilla, dehiscence was most detected in the mesial root of the first molar, with a rate of 19.58% ($P = .028$). The lowest rate (4.10%) was in the mesial root of the second molar. In the mandible, the highest (18.82%) rate was in the mesial root of the first molar ($P = .032$). The lowest (5.10%) rate was in the distal root of the second molar (Table 3).

Table 3 shows the distribution of the dehiscence types according to the classification of Yang et al.[15] In the maxilla, CI DI (29.80%) was the highest type, while the rarest type was CIII (5.10%) (Table 3). CI DI was statistically higher than CI DII, CII DI, CII DIII, and CIII ($P < .001$) in the maxilla.

In the mandible, types of CII DI, CII DIII, and CIII were not detected. CI DII was the highest type with a rate of 49.41%. The rates of CI DI and CI DIII were 24.70% equally. CI DII was statistically higher compared to other types ($P = .0013$).

For the interobserver reliability, there was no statistical difference between groups according to Cohen's kappa test ($P > .05$), and the kappa score was 0.92.

DISCUSSION

Fenestration was most commonly located in the maxillary first premolar, while dehiscence was most common in the mesial root of the maxillary first molar. According to our results, type III fenestration (involving the coronal third) and CI DII dehiscence (involving coronal and middle thirds) were the most common in Turkish human skulls. The null hypothesis that no difference would be detected between types of fenestration or dehiscence was rejected. This first study to analyze the presence of fenestration and dehiscence using the human skull with direct visual examination reported the defect prevalence as 18.80% in the Turkish subpopulation.

Meticulous knowledge must be obtained before periodontal surgery. If the presence of fenestration or dehiscence is detected during the mucogingival surgery, it disperses the prognosis of the treatment and moreover, causes changes in treatment planning.[8,14] In our study, fenestration and dehiscence existed equally in the maxilla and mandible, contrary to others that report a

Table 1. The Distribution of Fenestration and Dehiscence According to the Jaw and Teeth

								First Molar		Second Molar	
		Total	Central	Lateral	Canine	First Premolar	Second Premolar	Mesial	Distal	Mesial	Distal
Defect Type	Jaw	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)
Fenestration	Maxilla	100 (n=86)	-	6.97 (n=6)	17.64 (n=15)	28.23 (n=24)	6.97 (n=6)	11.62 (n=10)	9.30 (n=8)	15.11 (n=13)	4.65 (n=4)
	Mandible	100 (n=72)	12.50 (n=9)	12.50 (n=9)	16.66 (n=12)	12.50 (n=9)	12.50 (n=9)	11.11 (n=8)	5.58 (n=4)	11.11 (n=8)	5.58 (n=4)
	P	.64	-	.062	.35	<.001*	.56	.089	.012*	.058	.76
Dehiscence	Maxilla	100 (n=97)	12.37 (n=12)	12.37 (n=12)	16.49 (n=16)	12.37 (n=12)	7.21 (n=7)	19.58 (n=19)	10.30 (n=10)	4.10 (n=4)	6.18 (n=6)
	Mandible	100 (n=85)	8.23 (n=7)	10.58 (n=9)	14.11 (n=12)	16.47 (n=14)	9.41 (n=8)	18.82 (n=16)	11.76 (n=10)	7.05 (n=6)	5.88 (n=3)
	P	.12	.043*	.29	.85	.16	.098	.70	.82	.62	.036*

*Statistical difference according to chi-square and Fisher's exact test ($P < .05$).

Table 2. Fenestration Types According to Pan et al[4] Classification Among Teeth and Jaws

Jaw	Type	Total	Central	Lateral	Canine	First Premolar	Second Premolar	First Molar		Second Molar		P
		% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	Mesial % (n)	Distal % (n)	Mesial % (n)	Distal % (n)	
Maxilla	Type I	24.41 (n = 21)	-	3.48 (n = 3)	3.48 (n = 3)	10.46 (n = 9)*	4.65 (n = 4)	-	-	2.32 (n = 2)	-	<.001
	Type II	24.41 (n = 21)	-	3.48 (n = 3)	3.48 (n = 3)	6.97 (n = 6)*	-	3.48 (n = 3)	2.32 (n = 2)	5.81 (n = 5)	-	<.001
	Type III	9.30 (n = 8)	-	-	-	-	-	3.48 (n = 3)*	2.32 (n = 2)	2.32 (n = 2)	1.16 (n = 1)	.001
	Type IV	27.05 (n = 23)	-	-	6.97 (n = 6)	10.46 (n = 9)*	-	1.16 (n = 1)	1.16 (n = 1)	4.65 (n = 4)	2.32 (n = 2)	<.001
	Type V	5.81 (n = 5)	-	-	-	-	2.32 (n = 2)*	1.16 (n = 1)	1.16 (n = 1)	-	1.16 (n = 1)	<.001
	Type VI	8.13 (n = 7)	-	-	3.48 (n = 3)	-	-	2.32 (n = 2)	2.32 (n = 2)	-	-	.26
	Total	**100 (n = 86)**	**-**	**6.97 (n = 6)**	**17.64 (n = 15)**	**28.23 (n = 24)***	**6.97 (n = 6)**	**11.62 (n = 10)**	**9.30 (n = 8)**	**15.11 (n = 13)**	**4.65 (n = 4)**	**<.001**
Mandible	Type I	5.55 (n = 4)	-	-	-	-	-	-	5.55 (n = 4)	-	-	
	Type II	11.11 (n = 8)	-	-	-	5.58 (n = 4)	-	-	-	-	5.58 (n = 4)	.49
	Type III	38.88 (n = 28)	4.16 (n = 3)	12.50 (n = 9)*	4.16 (n = 3)	6.94 (n = 5)	-	5.58 (n = 4)	-	5.58 (n = 4)	-	.008
	Type IV	31.94 (n = 23)	8.33 (n = 6)	-	12.50 (9)*	-	-	5.58 (n = 4)	5.58 (n = 4)	-	-	.033
	Type V	12.50 (n = 9)	-	-	-	-	12.50 (n = 9)	-	-	-	-	-
	Type VI	-	-	-	-	-	-	-	-	-	-	-
	Total	**100 (n = 72)**	**12.50 (n = 9)**	**12.50 (n = 9)**	**16.66 (n = 12)***	**12.50 (n = 9)**	**12.50 (n = 9)**	**11.11 (n = 8)**	**5.58 (n = 4)**	**11.11 (n = 8)**	**5.58 (n = 4)**	**.042**

*statistical difference according to chi-square and Fisher's exact test ($P < .05$).

Figure 2. Types of fenestration and dehiscence. (A) Maxilla with type I fenestration. (B) Maxilla with type V and VI fenestration. (C) Mandible with Cl DI dehiscence. (D) Mandible with Cl DII dehiscence.

higher fenestration prevalence in the maxilla and a higher dehiscence prevalence in the mandible.[7,12,13] This difference can be attributed to racial factors or different methodologies. Another reason for various results may be related to the definition of defect. For instance, the definitions of dehiscence were different in various studies. While several studies defined it as the apically located bone crest of at least 4 mm,[8,13,14] others did not state any value in millimeters.[15,3,7,9]

Previous studies that used skulls reported a prevalence between 2.8% and 11.55% for fenestration and between 1.7% and 34.15% for dehiscence. Our study reporting 8.70% fenestration and 10.06% dehiscence rates are compatible with the literature. This study is the first report to analyze the fenestration and dehiscence with a direct visual examination using a skull in the Turkish subpopulation.

In our study, fenestration was most commonly observed in the maxillary first molar among all teeth. This result is compatible with a previous study performed in the Turkish subpopulation, which reported the highest fenestration prevalence in the first maxillary premolar compared to other teeth.[16] In addition to this study, in a previous report by the authors using CBCT in the Turkish subpopulation, they observed fenestration in 1 of the 2 maxillary first premolars.[19] In studies performed in the Turkish population, when considered in terms of racial factors, maxillary first premolar similarly showed a high fenestration rate. Besides, Pan et al[4] reported the most common fenestration in the maxillary first premolar in the Chinese population. Other studies performed in British,[8] American,[12] Egyptian,[3] North African,[13] or Mexican,[7] and South-East European[6] populations reported the most common fenestration was in the maxillary first molars.

Most studies reported that dehiscence was most common in the first molar and canines, respectively.[11-14] In our study, in the maxilla and mandible, dehiscence was most commonly located in the first molar, and mostly the mesial root was affected. Considering the first molars are the mastication center, the first located permanent teeth in the mouth, and are exposed to the centric and eccentric forces at most during mastication over time and

Table 3. Dehiscence Types According to Yang et al[1] Classification Among Teeth and Jaws

Jaw	Type	Total	Central	Lateral	Canine	First Premolar	Second Premolar	First Molar		Second Molar		P
		% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	Mesial % (n)	Distal % (n)	Mesial % (n)	Distal % (n)	
Maxilla	CI DI	29.89 (n = 29)	5.15 (n = 5)	2.06 (n = 2)	6.18 (n = 6)	-	-	5.15 (n = 5)	6.18 (n = 6)	3.09 (n = 3)	2.06 (n = 2)	.85
	CI DII	15.46 (n = 15)	-	1.03 (n = 1)	1.03 (n = 1)	4.12 (n = 4)	7.21 (n = 7)*	-	1.03 (n = 1)	-	1.03 (n = 1)	.018
	CI DIII	22.67 (n = 22)	5.15 (n = 5)	2.06 (n = 2)	3.09 (n = 3)	-	-	9.27 (n = 9)*	2.06 (n = 2)	1.03 (n = 1)	-	.016
	CII DI	10.30 (n = 10)	1.03 (n = 1)	2.06 (n = 2)	3.09 (n = 3)	4.12 (n = 4)	-	-	-	-	-	.273
	CII DIII	17.52 (n = 17)	1.03 (n = 1)	4.12 (n = 4)	3.09 (n = 3)	-	-	5.15 (n = 5)	1.03 (n = 1)	-	3.09 (n = 3)	.76
	CIII	5.15 (n = 5)	-	1.03 (n = 1)	-	4.12 (n = 4)*	-	-	-	-	-	.019
	Total	100 (n = 97)	12.37 (n = 12)	12.37 (n = 12)	16.49 (n = 16)	12.37 (n = 12)	7.21 (n = 7)	19.58 (n = 19)*	10.30 (n = 10)	4.10 (n = 4)	6.18 (n = 6)	.028
Mandible	CI DI	24.67 (n = 22)	2.35 (n = 2)	2.35 (n = 2)	1.17 (n = 1)	1.17 (n = 1)	3.52 (n = 3)	5.88 (n = 5)	5.88 (n = 5)	3.52 (n = 3)	-	.23
	CI DII	49.40 (n = 42)	5.88 (n = 5)	4.70 (n = 4)	2.35 (n = 2)	12.94 (n = 11)	5.88 (n = 5)	7.05 (n = 6)	3.53 (n = 3)	3.53 (n = 3)	3.53 (n = 3)	.45
	CI DIII	24.65 (n = 21)	-	3.48 (n = 3)	10.58 (n = 9)*	2.35 (n = 2)	-	5.88 (n = 5)	2.35 (n = 2)	-	-	.027
	CII DI	-	-	-	-	-	-	-	-	-	-	-
	CII DIII	-	-	-	-	-	-	-	-	-	-	-
	CIII	-	-	-	-	-	-	-	-	-	-	-
	Total	100 (n = 85)	8.23 (n = 7)	9.41 (n = 9)	14.11 (n = 12)	16.47 (n = 14)	9.41 (n = 8)	18.82 (n = 16)*	11.76 (n = 10)	7.05 (n = 6)	3.53 (n = 3)	.032

*statistical difference according to chi-square and Fisher's exact test ($P < .05$).

the mastication center, a higher prevalence of dehiscence is expected compared to other teeth.

Following the first molar, in our study, the first premolar (16.47%) and canine (14.11%) showed a high prevalence of dehiscence in the mandible, respectively. Previous reports found higher dehiscence in the mandibular canine.[6-8,12,13,20] The canine guides the mastication and occlusion and is located at the corner of the dental arc, consequently subject to prominent occlusal forces. Particularly in abnormal situations such as bruxism, these teeth may be more prone to loss of the surrounding alveolar bone.

Majority of the studies reported only the existence of fenestration and dehiscence. However, detecting the types of bone defects is substantial for understanding the severity of the defect and leads the treatment planning. Our study is the first to analyze bone defect types with the aid of systematic classification by direct visual examination of the skull. A few studies scrutinized the types of fenestration and dehiscence.[4,15,17] Without a detailed classification, previous studies reported defects with the involvement of the root third[6,14] or half[13] superficially. Edel divided the root into 2 and reported that 89.5% of fenestration was located in the apical half of the root. In our study, according to the classification of Pan et al,[4] types I, IV, and VI occupy the apical half of the root; consequently, 48.54% of fenestrations are located in the apical half. Analogically to our study, previous studies that divided the root into 3 reported the most common location as the apical third (ranging from 46% to 48.5%).[6,14] In Nimigean et al.'s study, the fenestration extended apical to the middle, analogical to type IV of our study, was 4.3%, considerably lower than our study, in which the most observed fenestration was type IV (29.50%). Race is one of the most important parameters for the difference in prevalence. Besides, meteorological differences affect the results; for instance, a previous study performed in skulls did not exclude the misalignment or malposition, which is closely correlated with the presence of the bone defect.[20]

We reported the most common type of fenestration in the maxilla which was type IV, located in the apical and middle thirds, while in the mandible, it was type III, which was located in the coronal third. Pan[4] reported that the most common one was type I and contrary to our study did not detect type III.

Since types IV, V, and VI, which involve 2/3 of the root, extend wider location compared to the other types, these types require more attention in mucogingival surgery for esthetic results. On the other hand, types I, IV, and V, which involve the apex of the root, are more related to the spread of an endodontic infection or extrusion of irrigation solution or other endodontic materials rather than esthetic concerns. Fenestrations located in the apical third, and involving the apical foramen have a unique clinical significance. When the apical foramen is involved, it could cause pain that might be misdiagnosed as pulpitis or periapical pathology.[21] A previous study that used CBCT reported that type I (involving the apical third) and type IV (involving the apical and middle third) were most commonly located in the maxilla in the Greek population.[17] We found that type I predominantly existed in the maxilla; however, type IV existed equally in the maxilla and in the mandible. In our study, type VI (involving the entire root) was 8% of all types in the maxilla and not shown in the mandible. According to the previous reports, the distribution of type VI was between 0% and 6%, similar to but a little lower than our result.[4,17]

Table 4. Previous studies that reported the prevalence of fenestration and dehiscence

Study	Race	Specimens	Total Prevalence	Fenestration	Dehiscence
Abdelmalek	Egyptian	154 skull	23.84%	9%	14.84%
Larato	Mexican-Indian	108 skull	7.5%	4.3%	3.2%
Elliott	American	52 skull	20.0%	10.93%	9.19%
Edel	North African	87 skull	15.35%	11.55%	3.8%
Davies	British	389 skull	13.6%	8.3%	5.3%
Rupprecht	American	146 skull	13.0%	9.0%	4.1%
Ezawa	Japanese	96 skull	13.1%	8.0%	5.1%
Grimound	French	81 skull	26.42%	11.22%	15.20%
Volchansky	South African	100 skull	8.3%	6.6%	1.7%
Volchansky	South African (Bantu)	43 skull	12.7%	6.2%	6.5%
Jordic-Srdjak	Croatican	163 skull	43.47%	9.32%	34.15%
Nimigean	South-East European	138 skull	12.80%	8.55%	4.25%
Tal	South African	100 skull	8.4%	2.8%	5.6%
Kalaitzoglou	Greek	432 CBCT	-	3.35%	-
Yağcı	Turkish	41 CBCT	26.51%	10.28%	16.23%
Pan	Chinese	306 CBCT	-	3.37%	-
Yang	Chinese	364 CBCT	-	-	8.5%
Our study	Turkish	297 skull	18.80%	8.70%	10.06%

According to the classification of Yang et al,[15] in our study, the most common dehiscence in the maxilla was CI DI, which is located in the coronal third, and in the mandible, it was CI DII, which is located in the coronal and middle thirds. This was congruent with Yang et al.[15]

In our study, the coexistence of fenestration and dehiscence, CII DIII, was observed at a rate of 0.9%, and all were in the maxilla. Yang et al[15] classified the coexistence of defects as dehiscence and reported that the prevalence of CII DIII was 0.47% in the Chinese population. Without using this classification, a previous study reported that the prevalence of coexistence was 0.3% in the Japanese population.[22] In our study, the types of fenestration and dehiscence were analyzed using dry mandibles and maxillae. According to dehiscence classification,[15] CII DII means dehiscence with the accompanied periapical lesion. It cannot be detected with direct measurement using a skull if the lesion did not reach the outline of the bone. Thus, we excluded this type of dehiscence from the study.

In our study, all fenestrations were in the buccal aspect of the root. For dehiscence, the prevalence of CIII, which means located on both sides, was 0.27% and mostly observed in the maxillary first premolar. However, it was not detected in the mandible. Previously, lingual defects were reported between 0.023% and 3.9%,[4,6,12,14] while others reported no lingual defects.[10,7,3,20,23]

In our study, type 5 and type 6 fenestrations and CII DI, CII DIII dehiscences, which are a larger root involvement, had a lower prevalence similar to previous reports.[4,15,17] This relatively lower prevalence can be explained by the fact that the wider involvement of the defect and insufficient bone support make the tooth more prone to loss, particularly in cases such as aggressive periodontitis, and true prevalence cannot be detected.

In the literature, the prevalence of fenestration and dehiscence was investigated using CBCT or skull. Investigation using CBCT is valuable for clinical judgment, but on the other hand, it is risky compared to the direct measurement, and when used as a method in prevalence studies, it will lead to skeptical results due to the presence of alveolar bone with dimensions below the voxel size cannot be detected and is considered as a bone defect.

The prevalence or distribution in many populations and every teeth group was analyzed using dry skulls with direct observation or CBCT. Besides, the classification of dehiscence and fenestration has been defined by studies using CBCT.[4,15] However, there is a major limitation of CBCT that disturbs the results. The presence of bone cannot be viewed under a thickness less than the voxel size of CBCT, meaning that the thin bone may be regarded as a defect area. Previous studies that used CBCT demonstrated that the fenestration and dehiscence rates were 2.5 times higher with a 0.25 mm voxel size[24] and 3 times higher with a 0.36 mm voxel size than exist.[25] It is obligatory to note that, even with a high resolution, that is, the 0.125 mm voxel size, bone <1mm cannot be detected and is assumed a defect area.[26] This result renders all of the examinations that use CBCT skeptical. Thus, the types of bone defects must be directly observed to rule out radiographic obstruction. Direct visual examination is highly accurate and reliable; however, it cannot be used in the clinic. Moreover, skulls must have been well prevented to hamper the formation of post-mortem defects.

The limitations of our study are the use of the skull in the examination of bone defects and the possibility that some defects have occurred post-mortem. Besides, the age and gender of the specimens were unknown; thus, the relationship was not detected. Moreover, the type of CII DII was excluded from the analysis. To complete the analysis of classification, further studies in different populations that analyze the defect types with a direct observation using a skull or cadaver and, in addition to direct observation, using a radiographic method to confirm a possible periapical lesion of the specimens are needed. The strength of our study is that it is the first study to examine the prevalence of fenestration and dehiscence in the Turkish subpopulation with high precision using the human skull with a direct visual examination. Besides, it is also the first study in the literature to examine bone defects within the scope of systematic classification using the skull.
Considering the limitations of the study, we concluded several results; fenestration and dehiscence were similar in the maxilla and mandible. The prevalence of fenestration and dehiscence was detected at 8.70% and 10.06%, respectively, as the first report in the Turkish subpopulation using a skull. Fenestration and dehiscence were most commonly detected in the maxillary first premolar and maxillary first molar, respectively. For fenestration, type IV (involving apical and middle thirds) was most common in the maxilla, while type III (involving the coronal third) and type IV were most common in the mandible. For dehiscence, CI DI (involving the coronal third) was most common in the maxilla,

while CI DII (involving the coronal and middle thirds) was most common in the mandible.

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Effect of Commercial Whitening Toothpastes on Color Stability and Surface Roughness of Two Different Composite Resins

Piyasada Bulunan Farklı Beyazlatıcı Diş Macunlarının İki Farklı Kompozit Rezinin Renk Stabilitesi ve Yüzey Pürüzlülüğü Üzerindeki Etkisi

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ABSTRACT

Objective: The aim of this in vitro study is to compare the effects of different whitening toothpastes on the color stability (CS) and surface roughness (SR) of 2 composite resins.

Methods: A hundred disc-shaped specimens were prepared from Filtek Z250 microhybrid and Charisma Topaz nanohybrid composite resins. The discs were divided into 5 subgroups: artificial saliva, Colgate Active Charcoal, Yotuel, Opalescence, and Sensodyne Promine toothpastes. The initial roughness and color values of the samples were measured. In order to evaluate the CS and SR, all specimens were subjected to coffee and brushing cycles. A three-way mixed analysis of variance was used to analyze the data. All analyses were performed considering $\alpha = 0.05$.

Results: While the Z250 composite showed higher ΔE values than the other composite ($P < .05$), no significant differences were observed between the composites regarding SR ($P > .05$). Among the whitening toothpaste groups, there were no significant differences in ΔE values ($P > .05$) except for the control group. After an 8-week cycle, the activated carbon-containing toothpaste group showed a higher SR than the control group ($P < .05$).

Conclusion: All toothpastes were effective in removing discoloration from composite resins, depending on the composite resin used. However, the whitening toothpastes tested (after 8 weeks of use) increased surface roughness regardless of the composite resins used, but not more than regular toothpaste (not containing a whitening ingredient).

Keywords: Composite resins, discoloration, surface roughness, toothpastes

ÖZ

Amaç: Bu in vitro çalışmanın amacı, farklı beyazlatıcı diş macunlarının iki kompozit reçinenin renk stabilitesi (CS) ve yüzey pürüzlülüğü (SR) üzerindeki etkilerini karşılaştırmaktır.

Yöntemler: Filtek Z250 mikrohibrit ve Charisma Topaz nanohibrit kompozit reçinelerinden yüz adet disk şeklinde örnek hazırlandı. Diskler beş alt gruba ayrıldı: yapay tükürük, Colgate Aktif Karbon, Yotuel, Opalescence ve Sensodyne Promine diş macunları. Örneklerin başlangıç pürüzlülük ve renk değerleri ölçüldü. CS ve SR'yi değerlendirmek için tüm örnekler kahve ve fırçalama döngülerine tabi tutuldu. Verilerin analizi için üç yönlü karma varyans analizi kullanıldı. Tüm analizler $\alpha = 0.05$ düzeyinde yapıldı.

Bulgular: Z250 kompoziti, diğer kompozite göre daha yüksek ΔE değerleri gösterirken ($P < .05$), kompozitler arasında SR açısından anlamlı bir fark gözlenmedi ($P > .05$). Beyazlatıcı diş macunu grupları arasında, kontrol grubu hariç ΔE değerlerinde anlamlı bir fark bulunmadı ($P > .05$). Sekiz haftalık döngü sonrasında, aktif karbon içeren diş macunu grubu, kontrol grubuna göre daha yüksek SR gösterdi ($P < .05$).

Sonuç: Tüm diş macunları, kullanılan kompozit reçineye bağlı olarak kompozit reçinelerden renklenmeyi gidermede etkiliydi. Test edilen beyazlatıcı diş macunları (sekiz haftalık kullanım sonrası),

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kullanılan kompozit reçinelere bakılmaksızın, ancak beyazlatıcı etkili olmayan diş macunundan daha fazla olmayacak şekilde yüzey pürüzlülüğünü artırdı.

Anahtar Kelimeler: Kompozit reçineler, renk değişimi, yüzey pürüzlülüğü, diş macunları

INTRODUCTION

Today, it is accepted as an integral part of esthetic beauty in modern societies, and a natural and bright smile is desired. It has been reported in the literature that most patients desire whiter teeth and are not glad about the color of their teeth. The demand for aesthetic and restorative needs has led to the development of varied treatment options. This desire for whiter teeth has increased the use of tooth-whitening products.[1-3] Tooth bleaching techniques are widely used, and effective methods are utilized to eliminate or lighten the stains on the teeth.[2] In modern dentistry, teeth whitening is applied by a dentist with whitening gels containing carbamide peroxide (CH_4 $N_2O.H_2O_2$) or hydrogen peroxide (H_2O_2) of home or office type, or with the removal and control of extrinsic stains.[1,3]

Alternatively, the desired aesthetic result can be achieved with the use of whitening toothpaste.[4] Whitening toothpastes are products containing specific abrasives and/or chemicals that optimize the removal of extrinsic stains.[1] It is thought that the use of whitening toothpaste is considered a less costly and more convenient option for teeth whitening.[3] Whitening toothpastes, in addition to the caries and gingivitis preventive properties of conventional toothpastes, also have a whitening feature thanks to the different active ingredients (peroxides, enzymes, abrasives, optical action agents, etc.) in their content.[4]

The most commonly used abrasives in whitening toothpastes are calcium carbonate, calcium phosphate, calcium pyrophosphate, hydrated silica, and sodium bicarbonate, which are mainly responsible for removing extrinsic stain. The efficiency of whitening toothpastes containing abrasives depends on the particle's hardness, form, distribution, and concentration in their content.[1,5] Whitening toothpastes containing oxidants and enzymes prevent discoloration by chemically changing the pigments that color the teeth.[6] A recent discovery on the market is whitening toothpastes containing activated charcoal, which is an extremely lightweight black carbon and ash residue hydrocarbon.[7] There are fluoride-containing products, as well as fluoride-free whitening toothpastes with activated charcoal. Currently, charcoal-containing products' popularity is increasing, and social media advertising may help to spread the use of this material. There is not yet scientific evidence of the safety or effectiveness of these products in the oral environment.[8,9]

The surface roughness (SR), gloss, and color stability (CS) of composite resins affect the aesthetic appearance of the teeth they are used to restore.[2] With the use of whitening toothpaste, it is aimed at minimizing the discoloration that occurs in composite restorations, which is an important aesthetic treatment option. Since it causes an increase in SR, whitening toothpastes have an important effect on the performance and quality of composite resins.

There are many investigations in the literature analyzing the effect of whitening toothpastes on the SR and CS of composite resins.[10-12] However, few studies have assessed how activated charcoal whitening toothpaste affects the change in CS and SR of composite resins with different contents. In addition, although whitening toothpastes are widely used, the cumulative effects they can have on teeth and restorations due to their different ingredients are a matter of concern.[13] Based on the aforementioned, the current study aimed to assess the impacts of whitening toothpaste on the CS and SR of different composite resins. The null hypotheses tested were as follows: (1) whitening toothpastes would not affect the discoloration of composite resins (2) whitening toothpastes would not affect the SR of composite resins, and (3) there would not be a significant difference in terms of color change and SR between the composite resins used, respectively.

MATERIAL AND METHODS

Since this study did not involve human/animal subjects, no ethical approval or informed consent was obtained.

Specimen Preparation

Z250 universal microhybrid composite (MH) (3M ESPE, USA) containing Bisphenol A glycidyldimethacrylate (bis-GMA) and Charisma Topaz nanohybrid composite (NH) (Heraeus Kulzer, Germany) without bis-GMA were used in the study. From each composite, 100 disc-shaped specimens with dimensions of 10 mm in diameter and 2 mm in thickness were produced in 1 increment. Each specimen's surface was covered with a transparent mylar strip, and the extra material was gently pushed out of the specimens using a microscope glass slide. The top surfaces of all specimens were polymerized for 20 seconds by applying a light-emitting diode polymerization light, 3M Elipar™ DeepCure-S (1470 mW/cm^2, 3 M ESPE, USA). Afterward, all samples were kept in distilled water for 24 hours at 37°C in order to complete their polymerization. The specimens were polished using serially (coarse, medium, fine, and superfine) aluminum oxide discs (Sof-Lex, 3 M ESPE, St. Paul, MN, USA) for 10 seconds per disc. Then, all specimens were stored in deionized water at 37° for 24 hours, in dark containers before any measurements were performed. Then, the initial color and surface roughness measurements were performed.

Experimental Groups

The composite samples were divided into 5 subgroups randomly (n=10/group) based on the toothpaste type (brand) used: group

Table 1. Composites Evaluated in the Study

Composite	Type	Matrix	Inorganic filler content (wt%/vol%)	Manufacturer
Z250 MH	Microhybrid	BisGMA, UDMA, BisEMA	Zirconium/silica, mean size of 0.6 mm; 60% vol., 82% wt.	3M ESPE, St. Paul, MN, USA
Charisma Topaz NH	Nanohybrid	TCD-DI-HEA, UDMA	Barium aluminum fluoride glass, pre-polymerized fillers 73% wt./58% vol.	Heraeus Kulzer, Wehrheim, Germany

Table 2. Toothpaste Ingredients and Artificial Saliva Formulation Used in the Study

Toothpaste	Manufacturer	Ingredient	Tooth Whitening Technology
Promine, Sensodyne	GlaxoSmithKline, Turkey	Sodium fluoride, aqua, sorbitol, hydrated silica, glycerin, potassium nitrate, PEG-6, sodium lactate, aroma, cocamidopropyl betaine, titanium dioxide, xanthan gum, sodium saccharin, sodium fluoride, PVM/MA copolymer, sodium hydroxide, and limonene.	Nil
Yotuel All in One Snowmint	Biocosmetics Madrid, Spain	Carbamide peroxide, aqua, sorbitol, hydrated silica, xylitol, glycerin, tetrapotassium pyrophosphate, papain, titanium dioxide, potassium phosphate, Xantham Gum, aroma, sodium fluoride, sodium saccharin, diazolidinyl urea, and CI 42090.	Carbamide peroxide
Opalescence Whitening	Ultradent Products, Inc., USA	Sodium fluoride 0.25%, w/w, glycerin, water (aqua), silica, sorbitol xylitol, flavor (aroma), poloxamer, sodium lauryl sulfate, carbomer, (Cl 42090), (Cl 19140), sodium benzoate, sodium hydroxide, (Cl 77019 Cl 77891), sucralose, and xanthan gum.	Abrasives
Colgate Optic White Active Charcoal	Colgate Palmolive, Poland	Aqua, sorbitol, hydrated silica, PEG-12, tetrapotassium pyrophosphate, sodium lauryl sulfate, aroma, potassium hydroxide, cellulose gum, phosphoric acid, cocamidopropyl betaine, sodium fluoride, sodium saccharin, xanthan gum, charcoal powder, mica, limonene, and CI 77891.	Activated charcoal and enzymes
Artificial saliva		KCl 624.73 mg/L, KH_2PO_4 326.620 mg/L, K_2HPO_4 804.712 mg/L, $CaCl_2.2H_2O$ 166.130 mg/L, $C_6H_6O_3$ 2.000 mg/L, $MgCl_2.6H_2O$ 58.96 mg/L, CMC-Na 10.000 mg/L, deionized water 1000 mL	Nil

1 with artificial saliva (AS) (negative control group), group 2 with fluoride content toothpaste (Sensodyne Promine) (positive control group), group 3 with carbamide peroxide content (Yotuel All in One Snowmint), group 4 with abrasive particle content (Opalescence), and group 5 with active carbon content toothpaste (Colgate Optical White Active Charcoal). The positive control group was Promine Sensodyne toothpaste, which has no whitening component in its formulation. The negative control group was artificial saliva. The experimental groups, the characteristics of the composite materials, toothpastes applied, and a formulation of artificial saliva are presented in Tables 1 and 2.

Toothbrushing and Coffee Cycle

Initial color and SR measurements were performed. In this cycle, the samples were first brushed for 5 seconds with an electric toothbrush (Triumph Professional Care 5000, Oral B Braun GmbH, Kronberg/Ts., Germany) in continuous mode. Then the samples were stored in a coffee solution 3 times a day for 15 minutes. At the end of the cycle, the samples were again brushed for 5 seconds and subsequently stored in artificial saliva throughout the night. All specimens were subjected to brushing and a coffee cycle (for 4 weeks and 8 weeks) to better imitate the daily routine (Figure 1).

A custom-made experimental set-up was prepared, and both the samples and electric toothbrush were fixed. The toothpastes were mixed with artificial saliva in a ratio of 1 : 3 and the samples were brushed with this slurry mixture with a standard force of 2 N.[14] For the coloring process of the samples, 15 g of instant coffee powder (Nescafé Classic; Switzerland; pH 5.56) was mixed with 200 mL of hot water and then allowed to cool to room temperature.

To complete a 24-hour cycle, samples were stored in artificial saliva between the brushing and coffee cycles. The toothpaste slurry was freshly prepared each time, and the artificial saliva was replaced daily. Considering the 2 minutes of brushing time per day, each specimen was brushed for 10 seconds (2 brush strokes per second).[14] At the end of this protocol, the specimens were rinsed with deionized water. Each sample was brushed by the same researcher, who was blind to all the prepared composite discs.

Color Change Measurement

Color measurements were made using a clinical spectrophotometer (VITA Easyshade V, Ivoclar Vivadent, Liechtenstein). During these measurements, the CIEDE2000 color system was used on a standard white background under D65 standard illumination. The spectrophotometer was calibrated each time using its calibration block according to the manufacturer's instructions. In order to obtain accurate measurements, care was taken to place the probe tip perpendicular to the center of the samples in each measurement.[15]

Color measurements were performed 3 times by a single operator, and then the mean value was calculated. Color measurements of the samples were conducted 3 times: initially (T0), after a 4-week cycle (T4), and after a 8-week cycle (T8). The color values of the samples were calculated through the L*, a*, and b*

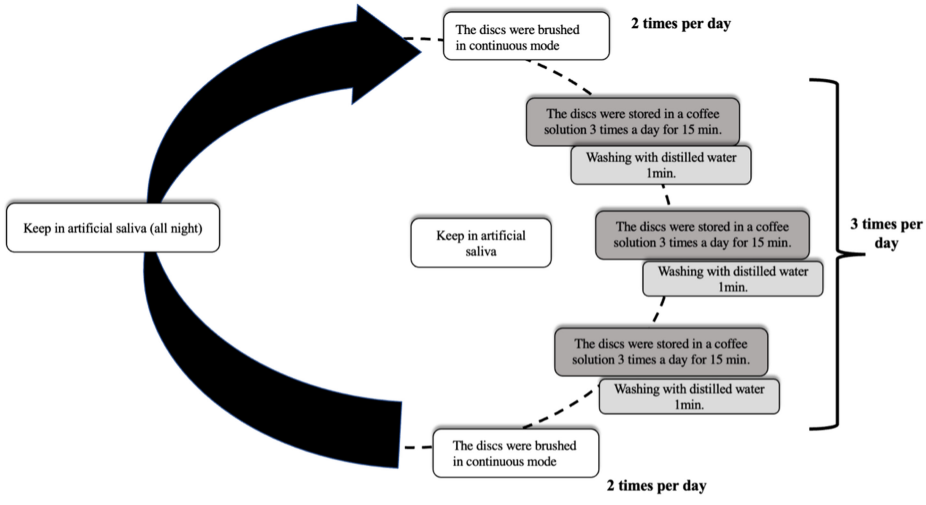

Figure 1. A schematic representation of the daily toothbrushing and coffee cycle.

parameters. The Obtained L*, a*, and b* parameters were entered into the CIEDE2000 formula (ΔE00) to detect coloring caused by the experimental conditions. The parameters KL, KC, and KH were all set to 1.

After 4 weeks, color measurement was performed, L_1*, a_1*, and b_1* values were recorded for each specimen, and ΔE1 values were calculated. The toothbrushing cycle was continued for another 4 weeks. After 4 weeks, the ΔE1 value was measured; 8 weeks after baseline L_2*, a_2*, and b_2* values were recorded for each specimen, and ΔE2 values were calculated. The formula below was used to calculate ΔE00 of the color change amounts between the obtained measurements.[16]

$$\Delta E_{00} = [(\frac{\Delta L}{k_L S_L})^2 + (\frac{\Delta C}{k_C S_C})^2 + (\frac{\Delta H}{k_H S_H})^2 + R_T (\frac{\Delta C}{k_C S_C})(\frac{\Delta H}{k_H S_H})]^{1/2}$$

According to the most recent guideline on color measurements issued by the International Organization for Standardization (ISO/TR 28642 2016), color stability should be based on the 50:50% acceptability (AT: ΔE_{00} = 1.77) and perceptibility (PT: ΔE_{00} = 0.8) thresholds.[15,16]

Surface Roughness Measurement

The SR was measured using a contact profilometer (Mahr Perthometer, Göttingen, Germany) with a tracing length of 5.6 mm and a cut-off value of 0.8 mm at the beginning and after the experimental period. In order to ensure repeatability, 2 lines were created on the samples with a marking (small drillings made with 1⁄4 burr) identifying the area. A reading was obtained by a diamond stylus moved at 0.5 mm/s, and then the arithmetic roughness (Ra) was recorded. This process was repeated in 3 positions on the same sample, and the average of these values was obtained. The measures were obtained by moving the diamond stylus across the sample surface and the reference areas perpendicularly to the direction of the movement of the toothbrush. The mean surface roughness values were calculated for each specimen.

Table 3. Color Change of Composite Materials, 4 and 8 Weeks After Exposure to Coffee and Brushing Cycles, According to Toothpaste Groups

Composite Resins	Group	Color Change After 4 Weeks ΔE00 mean ± SD	Color Change After 8 Weeks ΔE00 mean ± SD
3M Z250 (without Bis GMA)	Control	$3.31 \pm 0.22^{a,A}$	$3.25 \pm 0.23^{a,A}$
	Opalasense	$2.11 \pm 0.23^{b,A}$	$2.7 \pm 0.23^{b,A}$
	Yotuel	$2.08 \pm 0.41^{b,A}$	$2.01 \pm 0.34^{b,A}$
	Charcoal	$2.01 \pm 0.41^{b,A}$	$2.45 \pm 0.32^{b,A}$
	Promine	$2.58 \pm 0.29^{b,A}$	$2.55 \pm 0.32^{b,A}$
CharismaTopaz (with Bis GMA)	Control	$2.93 \pm 0.19^{a,B}$	$3.12 \pm 0.22^{a,B}$
	Opalasense	$1.61 \pm 0.24^{b,B}$	$1.63 \pm 0.3^{b,B}$
	Yotuel	$1.94 \pm 0.26^{b,B}$	$1.97 \pm 0.26^{b,B}$
	Charcoal	$1.72 \pm 0.28^{b,B}$	$1.52 \pm 0.28^{b,B}$
	Promine	$2.25 \pm 0.1^{b,B}$	$1.87 \pm 0.18^{b,B}$
Source of Variation		***P***	
Time		.521	
Composite resin		**.004**	
Toothpaste		**<.001**	
Time–composite resin		.154	
Time–toothpaste		.42	
Composite resin–toothpaste		.619	
Time–composite resin–toothpaste		.359	

Different lowercase letters (a, b) represent statistical differences among experimental groups for each composite resin ($P < .05$). Different uppercase letters (A, B) denote statistical differences among experimental toothpaste groups between brushing times ($P < .05$). In calculating the color difference of the samples, initial color values were taken as the baseline. It shows the statistically significant difference between rows (a-b) and columns (A-B) ($P < .05$). Only statistically significant effects were shown as bold values.

Scanning Electron Microscopy Analysis

After completing brushing and coffee cycles, 1 specimen from each group was randomly selected and analyzed via scanning electron microscopy. The specimen's surface was sputter coated with gold and palladium alloy in a vacuum evaporator, and photomicrographs of representative areas were obtained at ×1000 magnifications.

Statistical Analysis

Statistical Package for the Social Sciences Statistics software, version 21.0 software (IBM Corp.; Armonk, NY, USA), was used for the statistical analyses. The preliminary assessment of residuals' normal distribution and homogeneity of variances was checked by using Shapiro–Wilk's and Levene's tests. Roughness and color change were separately analyzed by a three-way mixed ANOVA (1 within-subjects factor, 2 between-subjects factors). To examine significant interactions, post hoc testing was performed using simple effect analysis with Bonferroni adjustment. All analyses were performed at a significance level of $\alpha = 0.05$.

RESULTS

Color Change Measurement (ΔE)

The effects of composite resin types, whitening toothpastes, and experiment time on the color change are given in Table 3. According to the results, the type of composite material and toothpaste were found to have an impact on color change ($P < .05$). However, no significant interactions were observed between "composite resin–time," "time–toothpaste," "composite resin–toothpaste," and "composite resin–time–toothpaste."

Regarding the color change on composite resins, MH showed higher ΔE00 values than NH ($P < .05$). Besides, all the toothpaste groups showed better results than the control group ($P < .05$). However, no significant differences in ΔE values were detected among the toothpaste groups ($P > .05$).

When the color change was evaluated for toothpaste groups and 2 composite materials over time, the color change on the MH composite and NH composite groups exceeded the established 50:50% perceptibility thresholds (ΔE00 > 0.81). Nevertheless, while the ΔE00 values of MH composite groups exceeded the determined 50:50% acceptability thresholds in all groups, only the NH composite+opalasence and NH+charcoal toothpaste groups did not exceed the 50:50% acceptability thresholds (ΔE00 < 1.77).

Surface Roughness Ra Measurement

The mean values of SR (ΔRa) with the respective standard deviations at different experiment times are illustrated in Table 4.

The results revealed that time ($P < .05$) and toothpaste ($P < .05$) affected surface roughness, while the type of composite material did not affect it ($P > .05$). Additionally, no significant interactions were detected between "composite resin–time," "composite resin–toothpaste," and composite resin–time-toothpaste.

While no significant difference was observed in the SR between the 2 composite materials ($P > 0.05$), the SR evaluation of toothpastes after 4 weeks showed no significant differences among them ($P > .05$). However, after an 8-week cycle, the activated carbon-containing toothpaste exhibited a higher SR than the control groups ($P < .05$).

Table 4. Surface Roughness of Composite Materials, 4 and 8 Weeks after Exposure to Coffee and Brushing Cycles, According to Toothpaste Groups

		Surface Roughness (initial)	Surface Roughness (After 4 Weeks)	Surface Roughness (After 8 Weeks)
Composite resins	**Group**	**SR mean ± SD**	**SR mean ± SD**	**SR mean ± SD**
3M Z250 (without Bis GMA)	Control	$0.293 \pm 0.025^{a\,C}$	$0.331 \pm 0.025^{a,B}$	$0.948 \pm 0.118^{b,A}$
	Opalascense	$0.286 \pm 0.022^{a,B}$	$0.341 \pm 0.017^{a,B}$	$1.45 \pm 0.192^{ab,A}$
	Yotuel	$0.259 \pm 0.016^{a,C}$	$0.415 \pm 0.05^{a,B}$	$1.351 \pm 0.253^{ab,A}$
	Charcoal	$0.325 \pm 0.028^{a,B}$	$0.366 \pm 0.029^{a,B}$	$1.672 \pm 0.314^{a,A}$
	Promine	$0.283 \pm 0.021^{a,B}$	$0.324 \pm 0.019^{a,B}$	$1.614 \pm 0.241^{ab,A}$
CharismaTopaz (with Bis GMA)	Control	$0.254 \pm 0.011^{a,C}$	$0.331 \pm 0.025^{a,B}$	$1.006 \pm 0.187^{b,A}$
	Opalascense	$0.238 \pm 0.014^{a,B}$	$0.281 \pm 0.018^{a,B}$	$1.386 \pm 0.184^{ab,A}$
	Yotuel	$0.239 \pm 0.012^{a,C}$	$0.27 \pm 0.021^{a,B}$	$1.509 \pm 0.256^{ab,A}$
	Charcoal	$0.248 \pm 0.013^{a,B}$	$0.304 \pm 0.024^{a,B}$	$1.653 \pm 0.265^{a,A}$
	Promine	$0.242 \pm 0.015^{a,B}$	$0.274 \pm 0.009^{a,B}$	1.603 ± 0.207^{ab}
Source of Variation			***P***	
Time			**<.001**	
Composite resin			.575	
Toothpaste			**.044**	
Time–composite resin			.732	
Time–toothpaste			.005	
Composite resin–toothpaste			.992	
Time–composite resin–toothpaste			.998	

Different lowercase letters (a, b) represent statistical differences among experimental groups for each composite resin ($P < .05$). Different uppercase letters (A, B) denote statistical differences among experimental toothpaste groups between brushing times ($P < .05$). In calculating the SR of the samples, initial SR values were taken as the baseline. It shows the statistically significant difference between rows (a-c) and columns (A-C) ($P < .05$).

Scanning Electron Microscopy Results

Scanning electron microscope micrographs of both composite resins used in this study after the 4-week and 8-week coffee and brushing cycles are depicted in Figures 2 and 3. Topographical changes were observed on the sample surfaces regardless of the toothpaste used after the coffee and brushing cycle.

DISCUSSION

The main drawback of resin-based composite resins utilized in aesthetic restoration is the unpredictability of color change and staining that takes place over time. Nowadays, there is a vast choice of different toothpastes on the market that are used to eliminate the discoloration problem. The effects of whitening toothpaste with different contents on the color change and SR of 2 composites were evaluated in this in vitro study.

The findings of the present study revealed that the tested toothpaste groups had an impact on the color (ΔE) of resin-based restorative materials. While there was no significant difference among the toothpaste experimental groups, all toothpaste groups exhibited lower discoloration compared to the control group. The first null hypothesis that "whitening toothpastes would not affect the discoloration of composite resins" was rejected. Soateman GD et al[17] reported that almost all dentifrices formulated expressly for teeth whitening are efficient at removing discoloration, whether or not a chemical discoloring agent is added. The findings of the present study regarding color change are in line with this conclusion.

The observed color changes after all toothpaste groups for MH composite resin were above the 50:50% acceptability and perceptibility thresholds (AT: ΔE00 > 1.77 and PT: ΔE00 > 0.8). It indicates that the composite materials had unacceptable color changes, which are probably plainly visible to standard viewers. The recorded color changes after all toothpaste groups for NH composite resin were above the 50:50% perceptibility thresholds (PT: ΔE00 > 0.8). However, in the abrasive and activated carbon-containing toothpaste groups, the recorded color change was below the 50:50% acceptable threshold (ΔE00 < 1.77). It means that, despite color changes on the composite materials, it is likely that standard observers would not notice them.

In 2013, the CIEDE2000 (ΔE00) formula was adopted as the standard for detecting color differences. The number of parameters used in the CIEDE2000 (ΔE00) formula increased and became more complex compared to the CIELAB (ΔEab) formula. Additionally, the CIEDE2000 (ΔE00) includes an interaction term between chroma and hue differences in addition to lightness, chroma, and hue weighting functions. Nevertheless, the more recent CIEDE2000 formula, which outperforms CIELAB and better correlates with visual findings, is advised for use in detecting color differences (ΔE00).[18] Gómez-Polo et al[19] revealed that they found the (ΔE00) formula to be more effective than the (ΔEab) in the evaluation of coloration. The main clinical significance of comparing color differences in dentistry is to understand their relationship with perceptibility and acceptability thresholds, rather than merely detecting statistical differences.[20] In this study, all these factors were taken into account when evaluating the impact of whitening toothpastes on the color change of composite resins, and the CIEDE 2000 system was also used.

In this study, coffee solution was selected as a coloring agent not only because of its widespread consumption but also for its great effect on the coloring of both teeth and composite resins.[21,22] In the routine, there is a short-term contact of food and drinks with teeth and resin materials before washing with saliva or brushing teeth.[23] Moreover, according to coffee producers, a coffee consumer consumes an average of 3.2 cups of coffee a day, and the consumption of 1 cup of coffee also takes an average of 15 minutes.[24] In this study, the samples were subjected to a cycle of soaking in coffee for 15 minutes 3 times and brushing twice a day for periods of 4 weeks and 8 weeks. Mara da Silva et al[23] applied a coffee and brushing cycle for 30 days in their studies, in which they evaluated the color change and surface hardness of 2 different composite resins. In light of all this information, the reason why there was no statistical difference in 2 time periods in terms of preventing the color change between toothpaste groups in the current study may be due to the cycle times applied in this study.

The current study evaluated composites with different polymer networks. An MH composite is a bis-GMA-based material, whereas an NH composite contains UDMA and TCD in its organic matrix and is bis-GMA-free. The third null hypothesis was rejected due to the results of this study showing a difference in terms of color change between the composite resins.

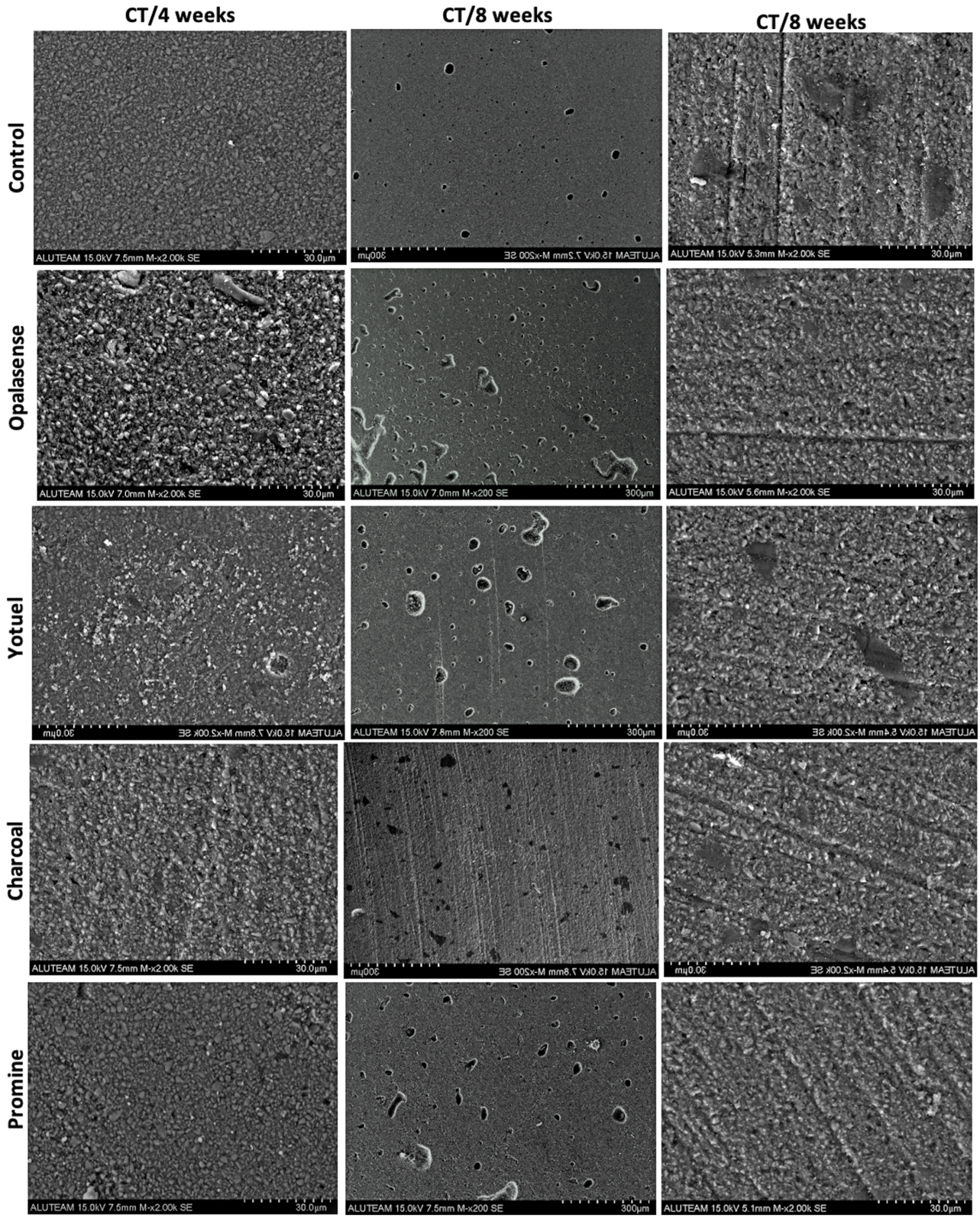

Figure 2. Representative scanning electron microscopy images of microhybrid composite resins.

The findings of the current study confirm that the color change of composite resins depends on the material used. Bis-GMA is the most widely used monomer in resin composites, showing less polymerization shrinkage than other monomers due to its large molecular weight. Hatipoglu et al[25] compared the color stability of composites with different monomer content in their study and found that the composite with bis-GMA content showed a higher discoloration. The discoloration of resin composites has been shown to be related to water absorption and solubility. Bis-GMA-based materials contain highly polar hydroxyl groups, resulting

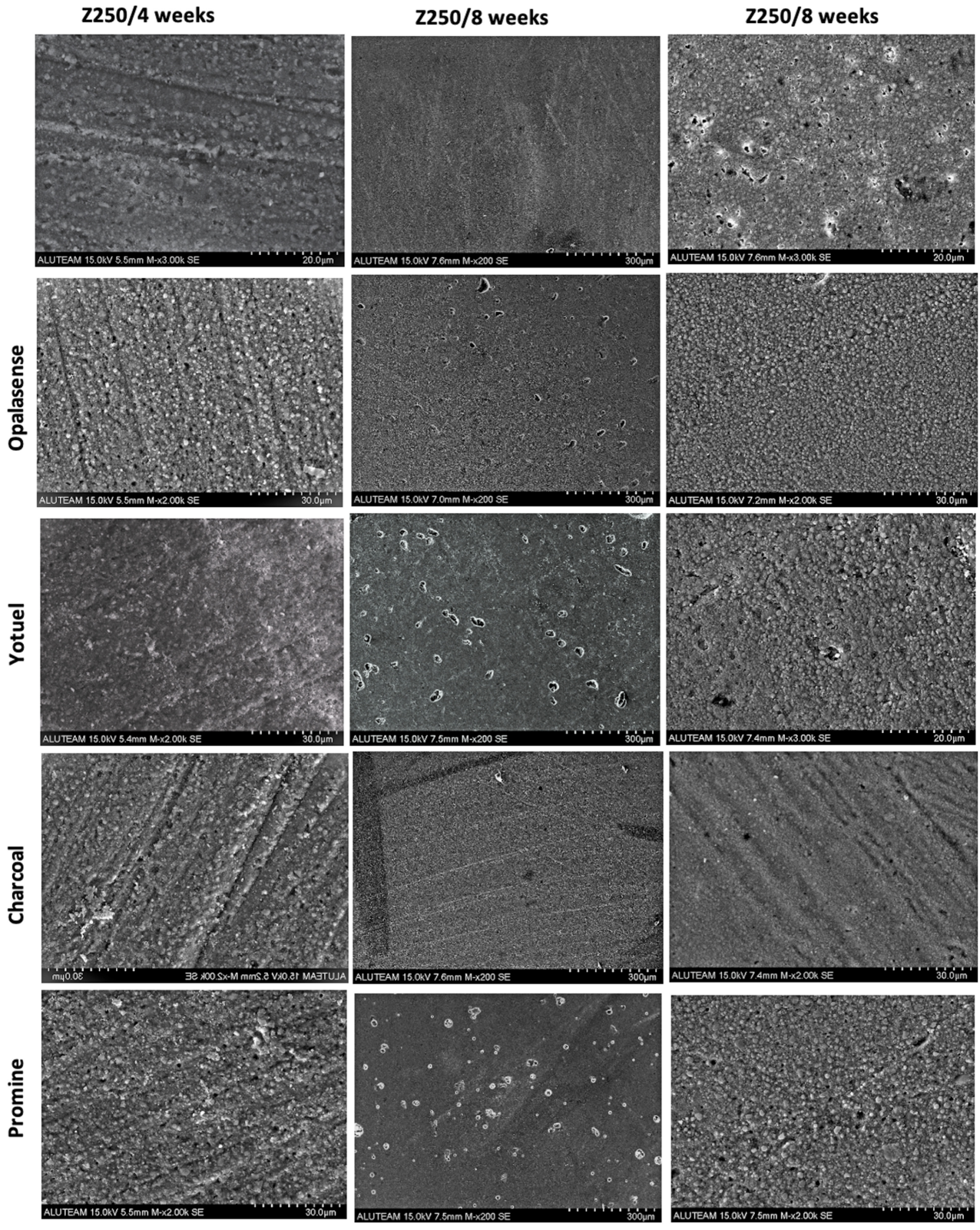

Figure 3. Representative scanning electron microscopy images of nanohybrid composite resins.

in high water absorption. In this study, it may have shown more color change due to Bis GMA in the MH content.[25]

A nanohybrid composite is a nanofilled resin-based composite with a smaller filler compared to the other composites examined in the study. After polishing, a smoother surface and a brighter appearance of this material were obtained. Composites become more sensitive to water absorption and color change as the filler particle size increases. This could be caused by the weakening of the bond between the matrix and the filler.[26] While the NH composite matrix is less hydrophilic, resulting in lower water absorption and water solubility, it consists of aliphatic chains; the matrix

of the MH composite consists of hydrophilic hydroxide groups.[27] The difference between composite resins in terms of color change in this study may occur because of these reasons.

Both composite resins used in this study showed positive values for Ra, which means the roughening of the materials depends on the toothpaste used and the duration of exposure. There was no difference between composite resins in terms of surface roughness, and the null hypothesis 3 can be accepted partially. The more tooth brushing cycles and periods there are, the more composite resin deterioration and surface roughness there is; on the other hand, the brightness is lower.[23] This result could be attributed to the increase in roughness caused by the gradual removal of filler particles during the tooth brushing process.[23] Whitening toothpastes have caused an increase in the surface roughness of composite resins over time, thus causing the second null hypothesis to be rejected.

The abrasiveness of toothpastes affects the surfaces of the studied composites. The greater the abrasiveness of the toothpaste, the greater the surface roughness of the material.[28] In this study, the surface roughness of the samples brushed with activated carbon toothpaste increased statistically.

The theoretically detectable surface roughness by the patient in composite restorations was determined to be 0.50 μm.[29] In this study, the roughness values exceeded this threshold after prolonged brushing. However, Shimokawa et al[30] stated that all tested composites in their study exhibited an increase in roughness surpassing this threshold after brushing, but they noted that the relevant threshold was reported in terms of profile roughness rather than surface roughness.

According to the literature, a profile roughness threshold of 0.2 μm has been reported for bacterial adhesion and retention.[31] According to this threshold, it can be expected that bacterial adhesion would increase in all groups after toothbrushing, even though bacterial adhesion was not specifically assessed in this study. Furthermore, a recent systematic review has emphasized that using a threshold alone is insufficient for accurately predicting bacterial adhesion.[32] However, it should be noted that Shimokawa et al[30] reported that this threshold was based on profile roughness measurements rather than surface roughness, which may render it impractical to compare the results of this study with the aforementioned threshold.

In the study of Alofi et al,[33] it was stated that the surface roughness increased significantly after the use of whitening toothpaste and activated charcoal powder compared to baseline measurements. In this study, it was observed that as the brushing duration increased, there was a tendency for an increase in surface roughness when composites were brushed with toothpaste. Therefore, it can be stated that longer brushing durations have a negative impact on the surface smoothness of resin composites. This potential increase in roughness can ultimately diminish the material's surface gloss, contribute to heightened plaque accumulation, and elevate the risk of dental caries and periodontal inflammation.[34]

The composite resins used in this study were more easily worn out than their organic matrix after 8 weeks of brushing with activated carbon toothpaste and exposure to extensive time.[5] Therefore, the surface roughness may have increased more (Figures 2 and 3). The abrasive effect of charcoal-containing products depends on particle size and distribution, as well as the manufacturing process.[33] The activated carbon toothpaste used in this study also contains hydrated silica abrasive particles. In addition, tetrapotassium pyrophosphate and cocomidopropyl betaine (a thickening and foaming agent) may also have been effective in increasing the performance of the paste.[5] Heintze et al[35] demonstrated that the abrasive content of toothpaste is effective on the SR of composites. The relatively greater number of grooves seen in the scanning electron microscope images of activated carbon groups is consistent with the outcomes of the study (Figures 2 and 3).

In this study, the effect of brushing teeth with Sensodyne Promine with fluoride content, which was used as a positive control group, on color change and surface roughness for both composite resins was found to be statistically similar to other whitening toothpastes. As a result, the presence of hydrated silica in the content of this conventional toothpaste with fluoride may have been effective. Among various abrasive agents, hydrated silica serves as an intermediate abrasive agent and is fairly effective in stain removal.[1]

In this study, the color and SR of the samples were evaluated after 4-week and 8-week cycles in order to imitate routine oral hygiene procedures. Specimens were individually subjected to 4 and 8 weeks of brushing in a regular oral hygiene Practice.[36] Studies evaluating stain removal or prevention typically have durations ranging from 2 to 6 weeks, with few studies evaluating whitening effects for extended periods of 12 weeks or more.[1] For these reasons, the effectiveness of whitening toothpastes was evaluated after 4 and 8 weeks of use in this study.

The primary limitation of this study is that the results are obtained in vitro. Additionally, the types of movement or the impacts of salivary dilution and lubrication are limited by in vitro studies. Therefore, further in vivo studies are needed to confirm the results of this study and to understand the effect behavior of whitening toothpastes on different substrates.

Within the limits of this study, it can be concluded that whitening toothpastes were found to be effective in removing the discoloration in composite resins, depending on the used composite resin, but showed no difference from a regular toothpaste. Whitening toothpastes promoted an increased surface roughness, regardless of the composite resins used, but did not increase it more than a regular toothpaste. Furthermore, after the 8-week cycle, toothpaste containing activated carbon exhibited greater surface roughness compared to the control group.

Ethics Committee Approval: Since there was no human/animal substrate in this study, no ethical approval was obtained.

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Assessment of the Topographic Relationship Between the Maxillary Sinus and Maxillary Posterior Teeth Using Cone Beam Computed Tomography

Maksiller Posterior Dişler ile Maksiller Sinüs Arasındaki Topografik İlişkinin Konik Işınlı Bilgisayarlı Tomografi Kullanılarak Değerlendirilmesi

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ABSTRACT

Objective: The aim was to identify the distance between the apices of maxillary posterior teeth and maxillary sinus (MS) floor as well as the thickness of the bone between the root and the alveolar cortical plate.

Methods: The cone-beam computed tomography scans of 74 patients were evaluated retrospectively. Topographic measurements of the surrounding bone at the apex of all premolar and molar maxillary teeth were performed in 2 different planes (vertical and horizontal). A 1-way analysis of variance was used to determine the differences in linear measurements between each root for all tooth types and genders.

Results: The mean vertical distance to the MS floor was significantly high for first premolar roots and the lowest mean vertical distance was measured for mesio-buccal roots of second molars ($P < 0.05$). In contrast, the lowest buccal bone thickness was found for the first premolar, whereas the highest buccal thickness was measured for the mesiobuccal roots of the second molars ($P < .05$). When gender groups were evaluated separately, it was found that the vertical distance between the apices of second premolar teeth and the MS floor was significantly higher in females ($P < .05$). Moreover, the mesiobuccal and palatal horizontal measurements of second molars were higher in females ($P < .05$).

Conclusion: It is important to have knowledge about the linear measurements and morphological features of the maxillary alveolar bone in order to carry out successfull dental practices The obtained results were expected to be beneficial for clinicians to reduce the complication, especially in dental procedures involving maxillary molar region.

Keywords: Maxillary sinus, maxillary molar, maxillary premolar, topographic measurements

ÖZ

Amaç: Maksiller posterior dişlerin apeksleri ile maksiller sinüs (MS) tabanı arasındaki mesafenin belirlenmesinin yanında alveolar kemiğin kortikal tabakası ile kökler arasındaki kalınlığın saptanmasıdır.

Yöntemler: 74 hastaya ait konik ışınlı bilgisayarlı tomografi görüntüsü retrospektif olarak değerlendirildi. Maksiller premolar ve molar dişlerin apeksleri hizasındaki alveolar kemiğin 2 farklı düzlemde (vertikal ve horizontal) topografik ölçümleri yapıldı. Çalışmaya dahil edilen tüm diş tipleri ve cinsiyet grupları için her diş köküne yönelik yapılan doğrusal ölçümler arasındaki farklılıkları belirlemek amacıyla tek yönlü varyans analizi kullanıldı.

Bulgular: MS tabanına olan ortalama vertikal mesafe birinci premolar dişlerde anlamlı derecede yüksek iken, en düşük ortalama dikey mesafe ikinci molar dişlerinmezio-bukkal kökleri için ölçüldü ($P < 0.05$). Buna karşılık en düşük bukkal kemik kalınlığı birinci premolar dişler bölgesinde iken, en

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yüksek bukkal kemik kalınlığı ikinci molar dişlerin mezio-bukkal köklerinde ölçüldü (P < .05). Yapılan ölçümler cinsiyet dağılımına göre karşılaştırmalı olarak değerlendirildiğinde, ikinci premolar dişlerin apeksleri ile MS tabanı arasındaki vertikal mesafenin kadınlarda anlamlı şekilde daha yüksek olduğu belirlendi (*P* < .05). Ayrıca ikinci molar dişlerin mesio-bukkal ve palatal yöndeki horizontal ölçümleri kadınlarda anlamlı şekilde yüksekti (*P* < .05).

Sonuç: Maksiller alveol kemiğin morfolojik özellikleri ve doğrusal ölçümleri hakkında bilgi sahibi olunması, dental uygulamaların başarılı olarak gerçekleştirilebilmesi için önemlidir. Elde edilen sonuçların, özellikle maksiller posterior bölgeyi ilgilendiren dental işlemlerdeki komplikasyonların azaltılmasında klinisyenlere faydalı olması beklenmektedir.

Anahtar Kelimeler: Maksiller sinüs, maksiller molar, maksiller premolar, topografik ölçümler

INTRODUCTION

The proximity between the root apices of maxillary posterior teeth and the maxillary sinus (MS) floor may cause some inflammatory and traumatic changes in the MS.[1,2] It was proved that bacterial infection(s) spreading via bone marrow, blood vessels, and/or lymphatics into the MS might create various pathological alterations.[3-5] Accordingly, many iatrogenic complications have been reported during and/or after root canal treatment of the maxillary posterior teeth due to their close anatomical relationship.[6] Moreover, it is well known that extraction of teeth with root tips close to the MS floor may cause an oro-antral fistula. Bacterial inflammation originating from periapical lesions and/or endodontic/surgical complications has all been considered as a predisposing factor for odontogenic maxillary sinusitis.[7] Furthermore, the relationship between the maxillary posterior teeth and the MS should be determined to prevent the intrusion of dental implants into the MS. Therefore, accurate knowledge of the anatomic relationship between the root apices of maxillary posterior teeth and sinus floor is crucial for both non-surgical and surgical dental procedures.[8,9] One of the important factors that must be determined during the planning of surgical procedures for the maxillary posterior region is the thickness of buccal and palatal bone in the area of operation. Knowledge of the buccal and/or palatal bone thickness before endodontic surgery is essential for the decision of the optimal surgical site and surgical approach, as well as the selection of the most appropriate implant width.[10,11]

Three-dimensional (3D) imaging methods and, recently, cone-beam computed tomography (CBCT) have become the standard for the evaluation of both hard and soft tissue components of the MS. It was reported that CBCT imaging facilitates the decision to perform the surgery either from the buccal or from the palatal side.[9,11,12] Moreover, the detailed 3D information provided by multiple thin sections of CBCT also facilitates the clinicians' understanding of the topography of the adjacent anatomical structures, thereby increasing the success of surgical procedure(s).[8]

Many studies have been conducted to evaluate the topographic relationship between the roots of maxillary posterior teeth and the MS floor.[8,11,13] However, reported findings were not comparable because some studies used low-resolution CT devices, while others preferred cone-beam CT.[10,13-15] Moreover, some studies included the evaluation of the relationship of the sinus floor with both the premolar and the molar root apices, while others only included the molar roots.[13,16] Furthermore, most of the studies did not include the measurement of bone thickness around root apices. Only 2 studies determined the distance between the apices of the all-maxillary posterior teeth and the sinus floor, including the measurement of the buccal and palatal bone thickness using CBCT images.[9,11]

Therefore, the objectives of this study were to identify the distance of the apices of maxillary premolar and molar teeth to the MS floor and the morphological features of the alveolar bone surrounding the related root apices using cone-beam CT images.

MATERIAL AND METHODS

Study Sample

Ethics Committee of the Ege University approved this study (Date: 29.12.2016, Number: 70198063-16-11.1/10) as regards the 1964 Declaration of Helsinki. Informed consent was obtained from all participants.

Cone-beam computed tomography scans taken for various diagnostic purposes at the Department of Oral and Maxillofacial Radiology between 2018 and 2019 were examined retrospectively. Cone-beam computed tomography scans of 400 patients were obtained, and 74 scans showing at least 1 exposed MS as well as first and second premolars and molars without any malformations or bony pathologies were chosen and included in the study. The exclusion criteria for the study were the following: patients with apical pathologies, total edentulism, bone lesions related to systemic diseases, tumors in the maxillary posterior region, and images with heavy artifacts.

The CBCT images were obtained using the Kodak 9000 3D (Carestream Health Inc., Rochester, NY, USA) system with the following settings: field of view 50x37 mm, a voltage of 70 kVp, and a tube current of 10 mA. Small volumes were particularly preferred for high-resolution images (76 μm). DICOM files of the selected volumes were transferred to a portable hard disk for measurement sessions.

Topographic Measurements

Cross-sectional images were used for all measurements. Topographic measurements of the surrounding bone at the apex of all premolar and molar teeth were performed in 2 different planes (vertical and horizontal) consistent with the method of Yoshimine et al[32] using the native software of the CBCT system (CS 3D Viewer Software, Carestream Kodak 9300 C; Rochester, New York, USA). Both measurements were accomplished on the axial and sagittal section images reconstructed by the medial line of the root crown at the maxillary premolar and molar teeth (Figure 1). Since bone thickness is not similar in male and female subjects, the measurements for 2 genders were separately evaluated.

Vertical measurements (distance between root apex and sinus floor) were performed from the root apex to the inferior cortical border of the MS along the longitudinal axis of the root for all

Figure 1. Cross-sectional cone-beam computed tomography images showing the vertical (green lines), buccal horizontal (red lines), and palatal horizontal (yellow lines) measurements of the alveolar bone areas around premolar and molar roots.

posterior maxillary teeth. Vertical measurements for molar teeth included the measurement of the distances from all [mesiobuccal vertical (MBV) and distobuccal vertical (DBV) and palatal vertical (PV)] root apices to the inferior cortical border of the MS, while vertical measurements of the premolar teeth were performed by measuring the distance from all root apices to the inferior cortical border of the MS (BV and PV) (Figure 1). Measurements were performed separately for each root of the maxillary posterior teeth and were recorded as "0" when the root apex touches the floor of MS.

Horizontal measurements were performed to determine the buccal and palatal bone thicknesses. Buccal bone thickness for molar teeth was measured as the horizontal distance between the buccal root apex and the outermost border of the buccal cortical plate along the longitudinal axis of the mesiobuccal horizontal (MBH) and distobuccal horizontal (DBH) roots, while the horizontal distance between the buccal root apex and the outermost buccal cortical border was measured for premolars (buccal horizontal, BH). The horizontal distance between the apex of the palatal root and the outermost border of the palatal cortical plate was recorded as the palatal bone thickness. Horizontal measurements for premolar and molar teeth were determined as the horizontal distance between the root apex and palatal surface of the alveolar bone separately (PH) (Figure 1). When there was no trabecular alveolar bone surrounding the root apices on buccal/palatal surfaces, horizontal measurement(s) were recorded as "0."

All measurements were done by a single oral and maxillofacial radiologist who had 10 years of experience in CBCT imaging. Measurements were repeated by the same evaluator after 2 weeks.

Statistical Analysis

All data were descriptively analyzed using Statistical Package for Social Science Statistics version 15.0 software (SPSS Inc.; Chicago, IL, USA). Means, SDs, and minimum and maximum values of the vertical and horizontal measurements were calculated for all tooth types and all roots. A 1-way analysis of variance was used to determine the differences in linear measurements between each root for all tooth types and genders. All premolar teeth included in the study were single-rooted. Accordingly, pairwise comparisons of bone thicknesses were done between measurements of the single root of premolars, while each root of the molar teeth was compared separately. Pairwise comparisons were performed by the least significant difference test. In order to calculate intra-examiner agreement, Cohen's kappa coefficient (κ) was used and scored according to the Landis and Koch scale (0.0-0.2; slight agreement; 0.21-0.40; fair agreement; 0.41-0.60; moderate agreement; 0.61-0.80; substantial agreement; and 0.81-1.0; almost perfect). A P-value less than .05 (typically $\leq$.05) was statistically significant. At the end of the study, a "post hoc" power analysis was conducted to justify the chosen sample size using the G*Power software version 3.1 (Düsseldorf University, Germany).

RESULTS

A total of 164 posterior teeth were assessed in 74 patients (males: 56.8%, females: 43.2%, mean age: 48.6 years). Among 164 teeth, 80 (48.8%) were premolars, while 84 (51.2%) were molars. Among the evaluated teeth, 42 teeth were first (25.6%), 38 teeth were second (23.2%) premolars, while 44 teeth were first (26.8%), and 40 teeth were second (24.4%) molars. The total number of evaluated roots was 332. The mean and SDs of a total of 744 horizontal

Table 1. Vertical Measurements Between Maxillary Posterior Teeth Roots and the Sinus Floor (mm)

Vertical (V) Measurement, mm (Mean ± SD)	First Premolar	Second Premolar	First Molar			Second Molar		
Root	BV=PV	BV=PV	MBV	DBV	PV	MBV	DBV	PV
Total	4.98 ± 0.8*†	2.18 ± 0.60*	1.70 ± 0.56*¶	1.45 ± 0.48*¶	1.40 ± 0.40*¶	0.62 ± 0.26*†¶	1.40 ± 0.77*	1.35 ± 0.95*
Female	5.56 ± 1.32	3.22 ± 0.90‡	1.87 ± 0.94	1.55 ± 0.89	1.58 ± 0.60	0.35 ± 0.22	3.35 ± 3.35	2.10 ± 1.78
Male	4.20 ± 1.08	0.75 ± 0.38‡	1.54 ± 0.68	1.35 ± 0.48	1.25 ± 0.56	0.74 ± 0.36	2.40 ± 077	2.44 ± 1.17

BV, buccal vertical; DBV, distobuccal vertical; MBV, mesiobuccal vertical; PV, palatal vertical. According to the least significant difference test (P < .05):
*shows the significant difference between distances of molar and premolar roots to the sinus floor.
†shows the significant difference between the distances of first premolar roots and mesiobuccal roots of second molars to the sinus floor.
¶shows the significant difference between the distances of mesiobuccal roots of second molars and all roots of first molars to the sinus floor.
‡shows the significant difference between gender groups for vertical measurements of second premolar.

Table 2. Horizontal Measurements Between Maxillary Posterior Teeth Roots and Buccal/Palatal Cortical Bone Plate (mm)

Horizontal (H) Measurement, mm [Mean ± SD]	First Premolar		Second Premolar		First Molar			Second Molar		
Root	BH	PH	BH	PH	MBH	DBH	PH	MBH	DBH	PH
Total	0.65 ± 0.15*†	4.97 ± 0.47‡	1.69 ± 0.30*†	5.25 ± 0.25‡	1.07 ± 0.29*†¶	2.01 ± 0.36*†	1.85 ± 0.38‡^	3.85 ± 0.26*†¶	2.38 ± 0.44*	3.03 ± 0.49‡^
Female	0.78 ± 0.21	5.22 ± 0.66	1.78 ± 0.45	5.43 ± 0.37	1.39 ± 0.50	2.71 ± 0.63	2.34 ± 0.58	5.13 ± 0.39§	3.25 ± 0.75	4.43 ± 0.60ß
Male	0.48 ± 0.19	4.64 ± 0.67	1.57 ± 0.41	5.02 ± 0.34	0.76 ± 0.29	1.30 ± 0.26	1.35 ± 0.46	3.30 ± 0.22§	2.22 ± 0.50	2.39 ± 0.60ß

BH, buccal horizontal; DBH, distobuccal horizontal; MBH, mesiobuccal horizontal; PH, palatal horizontal.According to the least significant difference test ($P < .05$):
*shows the significant difference between buccal horizontal thicknesses of first premolars and other teeth.
†shows significant difference between mesiobuccal horizontal thicknesses of second molar and other teeth.
¶shows significant difference between mesiobuccal horizontal thicknesses of second molar and first molar.
§shows the significant difference between gender groups for mesiobuccal horizontal thicknesses of second molar.
‡shows significant difference between palatal horizontal thicknesses of premolars and molars.
^shows significant difference between palatal horizontal thicknesses first molar and second molar.
ßshows the significant difference between gender groups for palatal horizontal thicknesses of second molar.

and vertical measurements are shown in Tables 1 and 2. Post-hoc power calculations at the level of α error probability = 0.05 indicated that the sample size is sufficient with 1.000 power and 2.473 effect size.

All premolar teeth included in the study were single rooted; therefore, a single vertical measurement was made by measuring the distance from the root apex of premolar teeth to the inferior cortical border of the MS, not separately from the buccal and palatal regions (BV=PV). The mean vertical distance measured between the root apices and inferior cortical border of the MS for the first and second premolar roots was compared with each root of the molar teeth. According to this comparison, the mean vertical measurements were smaller for all roots of the first and second molar teeth as compared to the first and second premolar roots ($P < .05$). The mean vertical distance to the MS floor was significantly greater for first premolar roots (4.98 ± 0.87 mm), whereas the lowest mean vertical distance was measured for the mesiobuccal roots of second molars (0.62 ± 0.26) ($P < .05$). When molar teeth were compared with each other, no difference was found between the vertical distances of distobuccal and palatal roots of first and second molar teeth and MS floor ($P > .05$). However, vertical distance between the MS floor and mesiobuccal roots of second molars was smaller than that of the first molar teeth ($P < .05$) (Table 1).

For pairwise comparisons of bone thickness measurements, the buccal bone thickness of premolars (BH) was compared with the buccal bone thickness of MBH and DBH molar roots separately. The lowest buccal bone thickness was found for the first premolar, whereas the highest buccal thickness was measured for the MB roots of the second molars ($P < .05$). When molar teeth were compared with each other as regards MB and DB roots separately, no difference was found between DBH measurements of the first and second molars ($P > .05$). However, MBH measurements of the second molar teeth were higher than those of the first molars ($P < .05$). Palatal horizontal thicknesses of the first and second premolar teeth were significantly higher than the PH thicknesses of all molar teeth ($P < .05$). Further, according to the molar teeth comparison, the PH thickness of the second molars was significantly higher than that of the first molars ($P < .05$) (Table 2).

When gender groups were evaluated separately, it was found that the vertical distance between the apices of second premolar teeth and the MS floor (BV=PV) was significantly higher in females ($P < .05$). Moreover, the MBH and PH measurements of second molars were significantly higher in females ($P < .05$). No statistically significant difference was found in the remaining measurements between genders (Tables 1 and 2).

The kappa analysis revealed that intra-examiner agreement ranged from good to almost perfect (range: 0.51-0.84).

DISCUSSION

Clinicians' knowledge about the relationship between the roots of posterior maxillary teeth and the alveolar bone surrounding the roots provides advantages for the success of many dental procedures, such as implant treatment, apicoectomy (endodontic surgery), and applications of orthodontic mini implants.[9,10] Many studies have been carried out to evaluate the relationship between the posterior maxillary teeth and adjacent structures.[9,11,14,17,18] Previous studies evaluating this relationship with different imaging modalities showed that the root apices of the maxillary molar teeth are generally very close to the MS floor as compared to the premolar teeth.[9,11,14,17,18] When the linear measurements in previous studies were evaluated according to specific tooth groups, it was seen that the shortest vertical distance to the MS floor was measured in maxillary second molars, whereas the furthest vertical distance was in first premolars. [9,11,14,17,18] In addition, most of the studies reported that the root closest to the floor of the MS is the mesiobuccal root of the second molar tooth.[11,17] Even though the results reported here support these findings, the measurement values obtained were higher than some of the existing studies.[19] Similar to previous studies, [9,11,17,18] only the coronal slices were used for all measurements in the present study. However, studies that performed measurements on CBCT images in 3 different planes found that measurements of all roots in the coronal planes were higher than those in the sagittal planes.[19] This difference between measurement values in various studies may be explained with CBCT slices (coronal or sagittal) selected by researchers to perform the measurements.

The results of the present study revealed that the distance between the root of the molar and sinus floor was the shortest for the mesiobucal roots of maxillary second molars. This finding confirms the possible complications related to the proximity of the second molars to the floor of the MS that may occur during surgical operations. Displacement of dental implant or roots into the MS, perforation of the MS floor (oroantral communication) during tooth extraction, and dental material extrusion used in root canal therapy can be considered among these complications.[9] It has been shown that sufficient alveolar bone is a prerequisite for long-term dental implant success.[20,21] However, many studies showed that the success rate for maxillary implants was less than that for mandibular implants because of the limited amount of bone volume and the MS pneumatization after tooth loss.[21] Maxillary sinusitis caused by dental implant insertion into the MS and projection of the dental implant into the MS cavity were the possible complications of dental implants that may occur at the maxillary region.[22] The risk of developing these complications in the second molar region increases due to the proximity of the second molars to the floor of the MS. Therefore,

it is essential to determine the anatomical relationships of the maxilla with a specific assessment of linear measurements for proper dental implant treatment in the maxilla.

Another important clinical problem encountered due to the vertical anatomical relationship between the roots of posterior teeth and MS is odontogenic maxillary sinusitis.[23] Considering that maxillary molars have a high periapical lesions risk compared to other tooth types, the periapical inflammation, especially in the buccal roots of molar teeth, can spread to the MS and cause odontogenic maxillary sinusitis.[1,9] The relationship between these anatomical structures should be considered to prevent an iatrogenic procedure and to minimize the risks of an infectious disease within the sinus. Therefore, clinicians should consider the possibilities of the above-mentioned complications during surgical and non-surgical treatments, especially for the buccal roots of second molar teeth.

In addition to the closeness to the MS, bone thickness surrounding the related root apices is an important factor during surgical operations. Information about anatomical structures is crucial for apicoectomy because visualization and access to the surgical site can be compromised when this information is missing. To date, it has been reported that the root apex closest to the buccal bony surface was the buccal root of the maxillary first premolar tooth, whereas the second molar was farthest from the buccal bony surface.[10,14] Although the findings obtained in this study were similar to the previous ones, the measurement values obtained for both buccal and palatal bone thickness were found to be higher than some of the existing studies.[11] The variation observed in bone thickness measurements in these studies can be attributed to the difference in the measurement regions. It has been shown that measurements performed at 3.0-mm resection level resulted in lower bone thickness measurement values as compared with the measurements at the apex level.[11] However, studies that performed measurements at the apex level confirmed that bone thickness in the apical region is relatively thicker than at the resection level,[8,10] as in our study.

It is well known that the thickness of buccal and palatal alveolar bones in the operation field is a crucial factor regarding both apical surgery and dental implantation.[13] Studies have proven that buccal horizontal bone thickness is lower than the palatal bone thickness in the premolar region,[9,13,24] which is in accordance with the findings of the present study. Although this fact may favor the buccal side for the surgical access of premolar teeth, in a clinical situation requiring the resection of the palatal root, the palatal plate may be more accessible, necessitating knowledge of the thickness of both buccal and palatal plates.[10,13] Moreover, the classical view for apical surgeries in the maxillary molar region is to perform the operations with a labial or buccal approach. However, recent studies evaluating the success rates of apical surgeries recommend a palatal approach for molar teeth in some special cases.[13] These findings once again reveal that the bone thickness surrounding tooth apices should be established before surgical procedures. In addition to endodontic surgical procedures, the measurement of the buccal and palatal bone thickness around root apices is important for implants' long-term stability and the aesthetics of the prosthetic superstructure. At this point, the dimensions of alveolar bone at the maxillary premolar region are critical, with the lowest horizontal bone thickness. Thus, clinicians should avoid traumatic extraction of maxillary first premolars, which may damage the thin buccal alveolar bone.[9]

Buccal and palatal bone plate thickness has vital importance not only for dental implant treatment in prosthetic rehabilitation but also for mini-implant placement for orthodontic purposes.[9,11,13] Mini-implants, also called the temporary anchorage devices [TADs], are utilized to provide intraoral orthodontic anchorage.[25] Factors affecting the stability of mini-screw implants include age, gender, site and side of implantation, as well as the craniofacial skeletal structure of the implantation area. At this point, alveolar bone thickness is important in terms of both selecting the proper implantation placement and safe insertion of mini-implants without any damage to anatomic structures such as blood vessels, teeth roots, and nerves.[26] The findings of the present study confirmed previous studies demonstrating the thickest bone over MB root of second molar[9,13,24] Thus, it has been considered that the maxillary buccal molar region is a proper and safe site for placement of mini-implants.

When the anatomical relationships assessed in our study were evaluated separately according to gender groups, it was noteworthy that females tended to have their premolar roots more distant from the MS compared to males. This finding can be explained by the fact that the premolar roots are generally longer in men than in women, and the MS shows larger dimensions on average in males than in women. The fact that the MS is larger on average in men than in women may be another explanation for this finding.[19] When the measurements made in the horizontal direction were evaluated according to gender differences, both the buccal and palatal bone thickness of the second molars in females were found to be significantly larger than those in males. Comparative analysis of tooth size discrepancies between males and females in several studies showed that females had statistically significantly smaller teeth than males.[27,28] It was thought that this may be the possible reason why both buccal and palatal bone thicknesses of molars were greater in females compared to males in the present study.

Previous radiographic studies evaluating the anatomical relationship between the maxillary posterior teeth and the alveolar bone have utilized many imaging modalities, such as panoramic radiographs, CT scans, or CBCT imaging modalities.[15,29] In this study, due to its capability to provide submillimeter accuracy, a CBCT imaging system was preferred for the linear measurements of the maxillary posterior region. Furthermore, it requires a shorter acquisition time, a reduced cost, and a lower radiation dose compared to conventional CT.[30,31] Since smaller voxel sizes and limited volume (field of view-FOV) scanning protocols provide better spatial resolution and diagnostic accuracy in CBCT imaging, it has been suggested that images obtained with a CBCT device with these technical features should be preferred for periapical region evaluations.[30] Studies investigating the efficacy of CBCT in performing orthodontic analyses have emphasized that images with a voxel size of less than 0.3 mm are required to detect minimal changes in bone thickness.[32] Similarly, Lavasani et al[17] stated that the most important limitation of their study was that the voxel size of the images they used was significantly larger than the limited-field CBCT scans, which was offered at as low as 0.076 mm. At this point, using a CBCT device with an FOV of 50 × 37 mm and a voxel size of 0.076 mm in the present study provided a high-resolution image, allowing measurements to be made with high accuracy. However, including only single-rooted premolars and a single population may be regarded as a limitation of this study for drawing generalized assumptions. Further multicenter studies, including many populations and double-rooted premolars, may

provide more accurate results reflecting the true morphological characteristics of the maxillary posterior region.

This CBCT-based study evaluated the relationship between the maxillary posterior tooth roots, surrounding alveolar bones, and MS. The presented findings may be useful for clinicians performing dental interventions such as mini-implant placement, dental implant treatment, and apical surgery involving the maxillary posterior region.

Ethics Committee Approval: Ethics committee approval was received for this study from Ege University (Date: 29.12.2016, Number: 70198063-16-11.1/10).

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Performance of Chat Generative Pretrained Transformer and Bard on the Questions Asked in the Dental Specialty Entrance Examination in Turkey Regarding Bloom's Revised Taxonomy

Türkiye'deki Diş Hekimliğinde Uzmanlık Eğitimi Giriş Sınavı Sorularına İlişkin ChatGPT ve Bard'ın Bloom'un Revize Edilmiş Taksonomisine Dayalı Performansı

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ABSTRACT

Objective: This study aimed to compare the performance of chat generative pretrained transformer (ChatGPT) (GPT-3.5) and Bard, 2 large language models (LLMs), through multiple-choice dental specialty entrance examination (DUS) questions.

Methods: Dental specialty entrance examination questions related to prosthodontics and oral and dentomaxillofacial radiology up to 2021, excluding visually integrated questions, were prompted into LLMs. Then the LLMs were asked to choose the correct response and specify Bloom's taxonomy level. After data collection, the LLMs' ability to recognize Bloom's taxonomy levels and the correct response rate in different subheadings, the agreement between LLMs on correct and incorrect answers, and the effect of Bloom's taxonomy level on correct response rates were evaluated. Data were analyzed using McNemar, Chi-square, and Fisher–Freeman–Halton exact tests, and Yate's continuity correction and Kappa agreement level were calculated ($P < .05$).

Results: Notably, the only significant difference was observed between ChatGPT's correct answer rates for oral and dentomaxillofacial radiology subheadings ($P = .042$; $P < .05$). For total prosthodontic questions, ChatGPT and Bard achieved correct answer rates of 35.7% and 38.9%, respectively, while both LLMs achieved a 52.8% correct answer rate for oral and dentomaxillofacial radiology. Moreover, there was a statistically significant agreement between ChatGPT and Bard on correct and incorrect answers. Bloom's taxonomy level did not affect the correct response rates significantly.

Conclusion: The performance of ChatGPT and Bard did not demonstrate a reliable result on DUS questions, but considering rapid advancements in these LLMs, this performance gap will probably be closed soon, and these LLMs can be integrated into dental education as an interactive tool.

Keywords: ChatGPT, Bard, artificial intelligence, large language models, dental education, multiple choice questioning

ÖZ

Amaç: Bu çalışmanın amacı, iki büyük dil modeli (LLM) olan ChatGPT (GPT-3,5) ve Bard'ın Diş Hekimliğinde Uzmanlık Eğitimi Giriş Sınavındaki (DUS) çoktan seçmeli sorular üzerindeki performansını karşılaştırmaktır.

Yöntemler: Görsel içerikli sorular hariç olmak üzere, 2021 yılına kadar olan protetik diş tedavisi ve ağız, diş ve çene radyolojisi ile ilgili DUS soruları LLM'lere sorulmuştur. Daha sonra LLM'lerden doğru yanıtı seçmeleri ve Bloom'un taksonomi düzeyini belirtmeleri istenmiştir. Veriler toplandıktan sonra, LLM'lerin Bloom taksonomi düzeylerini belirleyebilme becerileri ve farklı alt başlıklardaki

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doğru yanıt oranları, LLM'ler arasında doğru ve yanlış yanıtlara ilişkin uyumu ve Bloom taksonomi düzeyinin doğru yanıt oranları üzerindeki etkisi değerlendirilmiştir. Veriler Mc Nemar, Ki-kare ve Fisher Freeman Halton Exact testleri kullanılarak analiz edilmiştir, Yate's Continuity Düzeltmesi ve Kappa uyum düzeyi hesaplanmıştır ($P < .05$).

Bulgular: ChatGPT'nin doğru cevap oranları arasında tek anlamlı fark ağız, diş ve çene radyolojisi alt başlıkları arasında gözlenmiştir (P: .042; $P < .05$). Toplam protez soruları için ChatGPT ve Bard sırasıyla %35,7 ve %38,9 oranında doğru cevap verirken, her iki LLM de ağız, diş ve çene radyolojisi için %52,8 oranında doğru cevap vermiştir. Ayrıca, ChatGPT ve Bard arasında doğru ve yanlış cevaplar konusunda istatistiksel olarak anlamlı bir uyum saptanmıştır. Bloom'un taksonomi düzeyi doğru yanıt oranlarını anlamlı derecede etkilememiştir.

Sonuç: ChatGPT ve Bard, DUS soruları üzerinde güvenilir bir performans göstermemiştir, ancak LLM'lerdeki hızlı gelişmeler göz önünde bulundurulduğunda, performans açıkları muhtemelen yakında kapanacak ve bu LLM'ler interaktif bir araç olarak diş hekimliği eğitimine entegre edilebilecektir.

Anahtar Kelimeler: ChatGPT, Bard, yapay zeka, büyük dil modelleri, diş hekimliği eğitimi, çoktan seçmeli soru

INTRODUCTION

The rapid progress in artificial intelligence (AI) has given rise to optimistic prospects for its utilization within the medical domain. Among the various applications of AI, one noteworthy implementation involves large language models (LLMs). These models possess the ability to produce text resembling human language and respond to prompts by leveraging patterns acquired from extensive training on substantial volumes of textual data.[1,2] This potential of LLMs spans across diverse fields, encompassing medical education and aiding clinical decision-making through multilingual interaction.[1] In the domain of education, AI's evolution has introduced novel prospects for the transformation of established learning methodologies. Conventionally, medical education has depended on resources like textbooks, academic journals, and search engines such as PubMed (National Library of Medicine, Bethesda, Md, USA) for knowledge acquisition. Nonetheless, there has been growing emphasis on integrating multidisciplinary AI-based training to adapt to the evolving landscape of medical practices, and LLMs can also be used as a part of this AI-based training.[3]

Regarding LLMs, chat generative pretrained transformer (ChatGPT) also known as GPT-3.5 (OpenAI, San Francisco, Calif, USA) became the most popular one with more than a hundred million users.[4,5] This conversational AI embodies a lineage of LLMs termed the GPT series, underpinned by deep learning methodologies. ChatGPT delivers direct responses to queries rather than merely directing users to various websites as web search engines do, thereby enhancing the engagement and immediacy of the interaction. It is easy to access and available online, and it exhibits proficiency in addressing queries across various languages, including English, Turkish, and several other languages.[1,2] Following its public release on November 30, 2022, ChatGPT has garnered considerable prominence, particularly within the realm of education.[3] The favorable outcomes exhibited by ChatGPT in these evaluations suggest its potential utility as an educational tool within the medical domain.[3] Several studies have highlighted the coherent and informative nature of ChatGPT's responses, signifying its potential as an interactive tool for medical education, capable of augmenting learning and enhancing comprehension of intricate subjects.[1,5-8] However, it is reported that the outputs it produces are rooted in data acquired prior to September 2021, so some of the information it is revealing may not be relevant today. Therefore, to overcome this problem, companies are actively developing alternative LLMs and one such solution is Bard (Google Inc., Mountain View, Calif, USA). Released in March 2023, Bard distinguishes itself by its capacity to instantly access and assimilate real-time information from the internet while formulating responses. This unique trait fuels anticipation of Bard's efficacy across diverse domains that demand up-to-date insights.[1,9] Nonetheless, while the proficiency of ChatGPT in specialized medical multiple-choice question (MCQ) assessments across diverse medical domains, encompassing the United States Medical Licensing Exam, and other exams on orthopedics, cardiology, microbiology, gynecology, family medicine have been documented investigations into Bard's performance in medical education remain in their infancy, and direct comparisons between Bard and established LLMs are just commencing.[6,10-14] Importantly, there exists a notable absence of head-to-head evaluations between Bard and ChatGPT, particularly in the specific context of multiple-choice dental examinations.

Multiple-choice examinations represent the prevailing mode of assessment for gauging student learning due to their capacity for objective evaluation. They offer the advantage of efficiently covering a broad spectrum of concepts within a constrained time frame, affording students immediate formative feedback and supplying educators with achievement data, while also informing learning developers about student engagement levels.[15,16] Additionally, responding to MCQs, enables students to swiftly pinpoint gaps in their knowledge, which is valuable for directing future learning[17] However, it's important to prepare well-crafted MCQs to direct the students' future learning through critical thinking. In this pursuit, the application of Bloom's revised taxonomy, which is a hierarchical classification of cognitive learning objectives, has emerged as a strategy to design MCQs that effectively assess critical thinking competencies, with evidence suggesting that the incorporation of higher-order MCQs supports the cultivation of a profound comprehension of scientific processes.[16,18] This taxonomy not only finds utility in preparing MCQs but also in the realms of other assessments, teaching, and learning, providing an easily comprehendible and practical guideline for curriculum development.[19] According to this guideline, the verbs "remember" (formerly labeled as knowledge or recall in the original version of Bloom's taxonomy) and "understand" (previously called comprehension) constitute the lower-order questions, whereas the verbs "apply," "analyze," "evaluate," and "create" form the higher-order questions. These higher-order questions necessitate the application of advanced cognitive skills,

compelling students to employ their foundational knowledge in intricate ways.[16,19,20] Consequently, it is imperative for an LLM to adeptly discern the distinction between lower and higher-order questions, thus ensuring its capability to interpret these categories effectively for future utilization in the educational field, especially for preparing questions.[19]

Several studies have investigated LLMs' performance on their correct response rates in different medical fields according to lower and higher-order questions, and they reported them to be promising to be used in medical education.[5,9,12,18] However, to the best of the authors' knowledge, there is no study examining the ChatGPT's and Bard's performances on Bloom's taxonomy and their correct response rates in the dental field, so it's unclear whether these LLMs can be used confidently as a tool for dental education. Therefore, in this study, the Dental Specialty Entrance Examination (abbreviated as DUS in Turkish), which is taken in Turkey by candidates who want to receive specialty education in the schools of dentistry, is evaluated. This exam consists of MCQs, with 5 options for each question. It comprises 40 questions of basic sciences and 10 questions of each clinical science, which prosthodontics, oral and maxillofacial radiology, pediatric dentistry, endodontics, orthodontics, periodontology, oral and maxillofacial surgery, and restorative dentistry.[21] In this study, DUS questions of prosthodontics and oral and dentomaxillofacial radiology that the authors specialized on are evaluated to assess: 1- the performance of ChatGPT and Bard on the recognition of Bloom's taxonomy level of the MCQs, 2- the performance of ChatGPT and Bard on the correct response rate on MCQs related to subheadings of prosthodontics and oral and dentomaxillofacial radiology, 3- the agreement of ChatGPT and Bard on correct/incorrect answers, 4- the effect of Bloom's taxonomy level (lower or higher-order) on the correct response rate of LLMs and the LLMs' agreement on correct/incorrect answers to all questions according to Bloom's taxonomy level specified by the authors and thereby identify the LLMs' strengths and weaknesses, create awareness and pave the way for further research and development of LLMs to be used in dental education. Consequently, the null hypotheses were set as follows: (1) Bard outperforms ChatGPT on the recognition of Bloom's taxonomy level of the MCQs, (2) Bard outperforms ChatGPT on the correct response rate on MCQs related to subheadings of prosthodontics and oral and dentomaxillofacial radiology, (3) The LLMs have no agreement on correct and incorrect answers, (4) Bloom's taxonomy level, specified by the authors, affects the correct answer rate of the LLMs and the LLMs have no agreement on correct/incorrect answers to all questions according to Bloom's taxonomy level specified by the authors.

MATERIAL AND METHODS

All DUS questions on prosthodontics and oral and dentomaxillofacial radiology, up to the year 2021, were downloaded from the database of ÖSYM, which is a governmental institution established by the Turkish parliament to assess and place proficient applicants who seek admission to higher education programs by means of centralized examinations. The questions after 2021 were excluded since ChatGPT covers data up to 2021. In prosthodontics, 2 figure-containing and 2 canceled questions were excluded, and 126 questions were asked; in radiology, 7 questions containing radiography were excluded, and only 123 questions with text content were asked in Turkish, the same as in the ÖSYM database. Questions with images, charts, or tables were excluded since ChatGPT is adapted according to text input and the current version of Bard allows images only in English prompts.

Both authors independently categorized the questions as lower-order or higher-order according to Bloom's taxonomy. All categorization was performed blindly, without the knowledge of any LLM's responses to the questions. In addition, prosthodontic questions were classified under 7 main headings: dental morphology, complete dentures, removable partial dentures, fixed partial prostheses, materials science, implant-supported prostheses, temporomandibular joint (TMJ) disorders, and occlusion.[22] Oral and dentomaxillofacial radiology questions were classified under 2 main headings: (1) oral medicine and oral diagnosis, (2) oral radiology.[23]

The DUS questions, with the original text in Turkish, were entered individually into ChatGPT and Bard as prompts, and both were asked to respond from July 24 to 29, 2023. The prompt "Can you give the correct answer to the multiple-choice question above and categorize this multiple-choice question according to Bloom's taxonomy?" was entered also in Turkish, just after the DUS question, as can be seen in Figure 1. The "regenerate response" button was not used, and the first response was taken to be the final answer. The official answers provided by the ÖSYM were used to establish the proper answer to each question. Answers were categorized as correct (1) or incorrect (0) in a binary format. Questions that an LLM prefers not to answer were classified as incorrect.

Statistical Analysis

After data collection, IBM Statistical Package for the Social Sciences Statistics, version 22.0 software (IBM Corp.; Armonk, NY, USA) program was used for statistical analyses to evaluate the null hypotheses according to the findings in the study. In addition to descriptive statistical methods (frequency), the McNemar test, Chi-square test, Fisher–Freeman–Halton exact test, and Yate's continuity correction were used to compare qualitative data, and the Kappa agreement level was calculated. Significance was evaluated at $P < .05$ level.

RESULTS

According to the McNemar test results, as seen in Table 1, the agreement between the authors', ChatGPT's, and Bard's lower/higher-order classifications is statistically not significant (P: .001; $P < .05$). The Kappa agreement levels between the authors' and ChatGPT's and Bard's classifications were 66.1% and 35%, respectively, while the Kappa agreement level between ChatGPT and Bard's classifications was 21.4%. The examples of agreement and disagreement in the classification can be seen in Figure 1 and 2.

When the correct/incorrect answer rates according to the subheadings are evaluated (Table 2), it is found that there is no statistically significant difference between the correct answer rates of LLMs among the subheadings of prosthodontics ($P > .05$). When all prosthodontic questions are taken into consideration, the correct answer rate of ChatGPT is 35.7%, while the correct answer rate of Bard is 38.9%. Between the oral and dentomaxillofacial radiology subheadings, it was found that there is statistically no significant difference in terms of Bard correct answer rates ($P > .05$), but there is a significant difference in terms of ChatGPT correct answer rates (P: .042; $P < .05$). The correct answer rate of ChatGPT for oral medicine and oral diagnosis questions (64.7%) is significantly higher than for oral radiology questions (44.4%). In

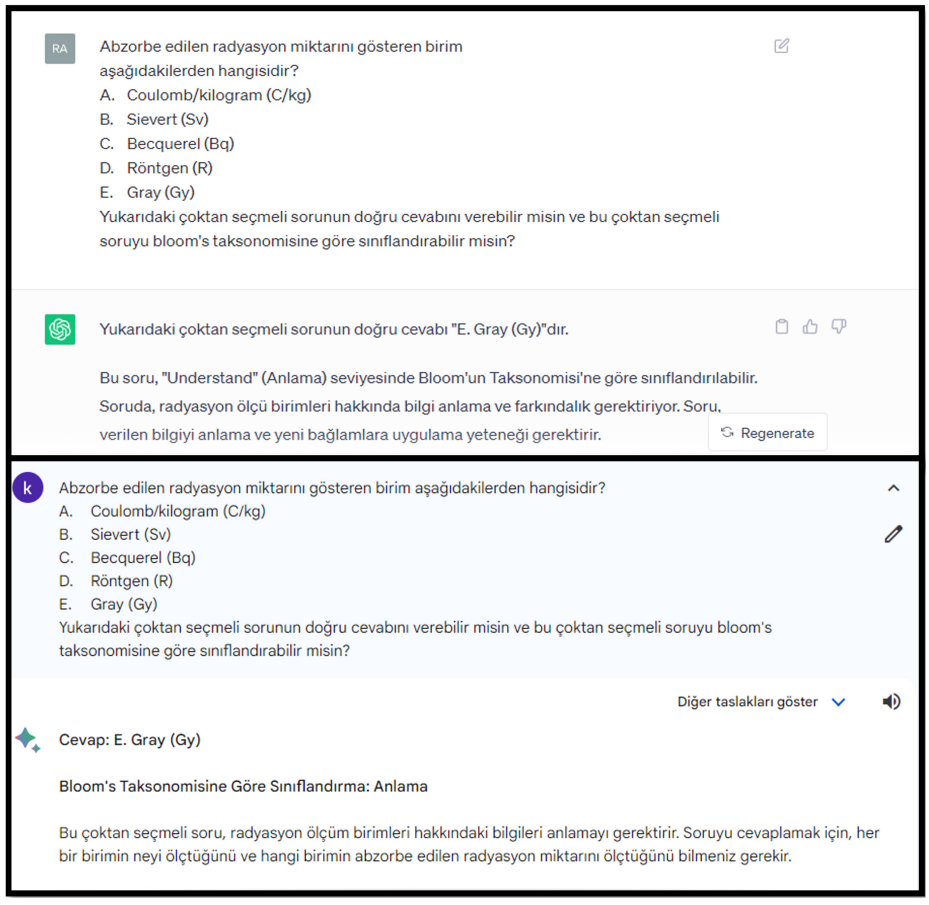

Figure 1. ChatGPT (upper screenshot) and Bard (lower screenshot) choose the correct answer (E.Gray) and define the same classification with the authors to the same question which is translated as, "Which of the following is the unit indicating the amount of absorbed radiation? A. Coulomb/kilogram (C/kg), B. Sievert (Sv), C. Becquerel (Bq), D. x-ray (R), E. Gray (Gy).

addition, for total oral and dentomaxillofacial radiology questions, the correct answer rates of both LLMs are 52.8%. The examples of correct and incorrect responses by both LLMs can be seen in Figure 1 and 2.

Upon evaluation of LLM's agreement on correct/incorrect answers to prosthodontics (Table 3) and oral and dentomaxillofacial radiology (Table 4) questions, it has been discovered that there is a statistically significant agreement on correct answer rates between the LLMS in terms of subheadings of both prosthodontics and oral and dentomaxillofacial radiology and in terms of total questions of both clinical sciences ($P > .05$). The inter-rater agreement, as indicated by the Kappa coefficient, between the 2 LLMs varies across different clinical sciences and their subheadings. For prosthodontics, the agreement level is 32.2% for all questions with the same answer rate of 86/126. In the realm of oral and dentomaxillofacial radiology, it stands at 28.2% for all questions with 79/123 having the same answer rate. Delving into specific subheadings, the agreement percentages are as follows: 52.6% for dental morphology, 45.1% for complete dentures, 14.3% for removable partial dentures, 15.4% for fixed partial prostheses, 20.8% for materials science, and 53.2% for TMJ disorders and occlusion. Meanwhile, for oral medicine and oral diagnosis, the agreement level is 29.7%, and for oral radiology, it is 24.8%.

Table 1. Agreement between the authors', ChatGPT's, and Bard's lower- and higher-order classifications (N = 249)

		Authors' Classification			
		Lower	Higher	*Total*	
		n (%)	n (%)	n *(%)*	*P*
Chat GPT's classification	Lower	200 (80.3)	19 (7.6)	*219 (88)*	
	Higher	3 (1.2)	27 (10.8)	*30 (12)*	<.001*
	Total	*203 (81.5)*	*46 (18.5)*	*249 (100)*	
Bard's classification	Lower	142 (57.0)	9 (3.6)	*151 (60.6)*	
	Higher	61 (24.5)	37 (14.9)	*98 (39.4)*	<.001*
	Total	*203 (81.5)*	*46 (18.5)*	*249 (100)*	
		ChatGPT's Classification			
		Lower	Higher	*Total*	*P*
Bard's classification	Lower	144 (57.8)	7 (2.8)	*151 (60.6)*	
	Higher	75 (30.1)	23 (9.2)	*98 (39.4)*	<.001*
	Total	*219 (88.0)*	*30 (12.0)*	*249 (100)*	

ChatGPT, Chat generative pretrained transformer.
*$P < .05$—McNemar test.

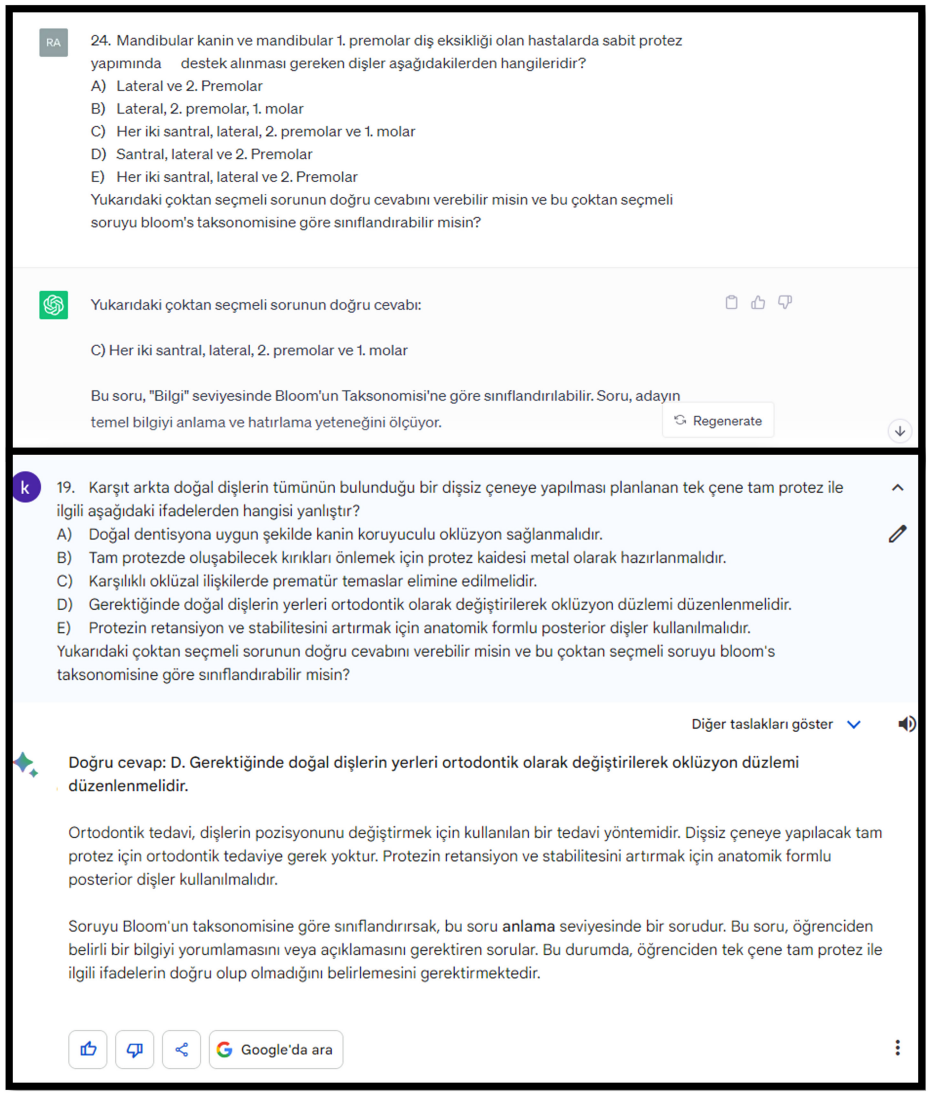

Figure 2. The upper screenshot presents ChatGPT choosing the incorrect answer (C. Both central, lateral, second premolar, and first molar) for the question "Which of the following are the teeth that should be prepared to support a fixed prosthesis in patients with mandibular canine and mandibular first premolar tooth loss?" (The correct answer is option D. Central, lateral, and second premolar) and defining the different classifications of Bloom's taxonomy (knowledge/remembers classified as lower-order) compared to the authors' (applications classified as higher-order). The lower screenshot presents a question translated as "Which of the following statements about a single jaw complete denture planned for an edentulous jaw with all-natural teeth in the opposite arch is incorrect? A. Canine-protected occlusion should be provided in accordance with the natural dentition. B. The denture base should be prepared as metal to prevent fractures that may occur in the complete denture. C. Premature contacts in interocclusal relationships should be eliminated. D. When necessary, the plane of occlusion should be adjusted by orthodontically replacing the natural teeth. E. Anatomically shaped posterior teeth should be used to increase the retention and stability of the prosthesis. This lower screenshot presents Bard choosing the incorrect answer (option D) whereas the correct answer is option A Bard further explains incorrectly that, "Orthodontic treatment is a treatment method used to change the position of the teeth. Orthodontic treatment is not required for a complete denture for an edentulous jaw. Anatomically shaped posterior teeth should be used to increase the retention and stability of the prosthesis."and defines the classification of Bloom's taxonomy differently (comprehension classified as lower-order) compared to the authors' (application classified as higher-order).

Regarding the effect of Bloom's taxonomy level, as specified by the authors, on the correct response rate of LLMs, as Bloom's taxonomy level increased, the LLM's performance decreased, but the difference was not statistically significant (Table 5). For lower-order questions, the correct response rates of ChatGPT for prosthodontics and oral and dentomaxillofacial radiology questions are 37.5% and 57.6%, while Bard's are 43.3% and 53.5%, respectively. For higher-order questions, ChatGPT's correct response rates for prosthodontics and oral and dentomaxillofacial radiology questions are 27.3% and 33.3%, whereas Bard's are 18.2% and 50%, respectively. In addition, regarding the LLMs' agreement on correct/incorrect answers to all questions according to the authors' lower or higher-order classification (Table 6), it is found that, in both the categorization of prosthodontics and oral and dentomaxillofacial radiology questions as lower or higher-order, a statistically significant agreement in terms of correct response rates is observed between ChatGPT and Bard ($P > .05$).

DISCUSSION

In this study, the performance of ChatGPT and Bard on DUS questions, specifically prosthodontics and oral and dentomaxillofacial radiology questions, was evaluated. According to the results, (1) ChatGPT outperformed Bard on the recognition of Bloom's taxonomy level of MCQs, but the agreement between both LLMs

Table 2. Evaluation of Correct/Incorrect Answer Rates of Chat Generative Pretrained Transformer and Bard According to the Subheadings

		Dental Morphology	Complete Dentures	Removable Partial Dentures	Fixed Partial Prostheses	Materials Science	Implant-Supported Prostheses	TMJ Disorders and Occlusion	Total	
		n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	*P*
ChatGPT	Incorrect	7 (77.8)	11 (57.9)	21 (77.8)	15 (55.6)	15 (68.2)	1 (25)	11 (61.1)	81 (64.3)	[1].333
	Correct	2 (22.2)	8 (42.1)	6 (22.2)	12 (44.4)	7 (31.8)	3 (75)	7 (38.9)	45 (35.7)	
Bard	Incorrect	5 (55.6)	12 (63.2)	21 (77.8)	18 (66.7)	10 (45.5)	0 (0)	11 (61.1)	77 (61.1)	.059
	Correct	4 (44.4)	7 (36.8)	6 (22.2)	9 (33.3)	12 (54.5)	4 (100)	7 (38.9)	49 (38.9)	
		Oral Medicine and Oral Diagnosis					Oral Radiology		Total	*P*
		n (%)					n (%)		n (%)	
ChatGPT	Incorrect	18 (35.3)					40 (55.6)		58 (47.2)	[2].042*
	Correct	33 (64.7)					32 (44.4)		65 (52.8)	
Bard	Incorrect	21 (41.2)					37 (51.4)		58 (47.2)	[3].264
	Correct	30 (58.8)					35 (48.6)		65 (52.8)	

ChatGPT, chat generative pretrained transformer; TMJ, temporomandibular joint.
[1]Fisher–Freeman–Halton exact test.
[2]Yate's continuity correction.
[3]Chi-square test.
*$P < .05$.

and authors was still not significant; (2) there was no statistically significant difference between the LLMs related to the correct response rate of MCQs on subheadings of prosthodontics and oral and dentomaxillofacial radiology; (3) there is a statistically significant agreement on correct answer rates between the LLMs in terms of subheadings of both prosthodontics and oral and dentomaxillofacial radiology and in terms of total questions of both clinical sciences; (4) Bloom's taxonomy level, specified by the authors, did not have a significant effect on performance of both LLMs, and the LLMs had a significant agreement on correct/incorrect answers to all questions according to the Bloom's taxonomy level specified by the authors. Therefore, the null hypotheses are all rejected.

Large language models can be used in education not only in answering questions but also in preparing questions. However, in order to be able to prepare questions that force students to use their critical thinking skills for an effective evaluation, it is important to prepare questions according to Bloom's taxonomy. Therefore, it is crucial to determine how effective LLMs are at recognizing Bloom's taxonomy in order to benefit from these LLMs when preparing questions.[8] However, according to the results of this study, both LLMs do not have a statistically significant agreement with the authors on specifying Bloom's taxonomy level as lower or higher order. An example of this disagreement is that when Bard was asked, "Which of the following impression materials should not be disinfected with chlorine solutions?" it classified this question in application level and thereby categorized it as higher-order, but the authors classified it in remember level as it was a simple knowledge question not requiring critical thinking and thereby categorized it as lower-order. As far as the authors searched, there is no similar study on LLMs' recognition of Bloom's taxonomy in the literature, but it was reported that there is no gold standard for making a lower or higher-order classification according to Bloom's taxonomy.[20] Also in another study, educators, faculty, and students were asked to classify questions as lower or higher-order according to Bloom's taxonomy, but the agreement between them was not significant, just like the results of the present study.[19]

Regarding the results on the correct response rate on questions related to subheadings of prosthodontics and oral and dentomaxillofacial radiology, the only significant difference was observed between ChatGPT's correct answer rates for oral and dentomaxillofacial radiology subheadings, which is significantly higher for oral diagnosis and oral medicine questions. This might be because ChatGPT was trained more, or users sought more medical advice and provided feedback on that subheading, leading to its continuous improvement.[3,5,24] For total prosthodontic questions, ChatGPT and Bard achieved correct answer rates of 35.7% and 38.9%, respectively, while both LLMs achieved a 52.8% correct answer rate for oral and dentomaxillofacial radiology. These rates are quite low, according to a recent study mentioning that for the LLM to become a reliable and widely acceptable educational tool, it should consistently provide 95% accuracy. In addition, other studies on the MCQ performance of ChatGPT in medical examinations also revealed that it was not successful enough to be used as an educational tool in gastroenterology, neurosurgery, urology, parasitology, and ophthalmology.[3,8,9,11,25,26] Furthermore, a recent report on the performance of ChatGPT and Bard on nephrology concluded that both LLMs had similar scores and were both insufficient.[1] Several factors could account for the relatively insufficient performance of these LLMs in certain

Table 3. Chat Generative Pretrained Transformer's and Bard's Agreement on Correct/Incorrect Answers to Prosthodontics Questions

		ChatGPT*			
		Incorrect	Correct	Total	
Subheadings	Bard**	n (%)	n (%)	n (%)	*P*
Dental morphology	Incorrect	5 (55.6)	0 (0)	*5 (55.6)*	
	Correct	2 (22.2)	2 (22.2)	*4 (44.4)*	.500
	Total	*7 (77.8)*	*2 (22.2)*	*9 (100)*	
Complete dentures	Incorrect	9 (47.4)	3 (15.8)	*12 (63.2)*	
	Correct	2 (10.5)	5 (26.3)	*7 (36.8)*	1.000
	Total	*11 (57.9)*	*8 (42.1)*	*19 (100)*	
Removable partial dentures	Incorrect	17 (63)	4 (14.8)	*21 (77.8)*	
	Correct	4 (14.8)	2 (7.4)	*6 (22.2)*	1.000
	Total	*21 (77.8)*	*6 (22.2)*	*27 (100)*	
Fixed partial prostheses	Incorrect	11 (40.7)	7 (25.9)	*18 (66.7)*	
	Correct	4 (14.8)	5 (18.5)	*9 (33.3)*	.549
	Total	*15 (55.6)*	*12 (44.4)*	*27 (100)*	
Materials science	Incorrect	8 (36.4)	2 (9.1)	*10 (45.5)*	
	Correct	7 (31.8)	5 (22.7)	*12 (54.5)*	.180
	Total	*15 (68.2)*	*7 (31.8)*	*22 (100)*	
Implant-supported prostheses	Incorrect	0 (0)	0 (0)	*0 (0)*	
	Correct	1 (25)	3 (75)	*4 (100)*	.250
	Total	*1 (25)*	*3 (75)*	*4 (100)*	
TMJ disorders and occlusion	Incorrect	9 (50)	2 (11.1)	*11 (61.1)*	
	Correct	2 (11.1)	5 (27.8)	*7 (38.9)*	1.000
	Total	*11 (61.1)*	*7 (38.9)*	*18 (100)*	
All questions	Incorrect	59 (46.8)	18 (14.3)	*77 (61.1)*	
	Correct	22 (17.5)	27 (21.4)	*49 (38.9)*	.636
	Total	*81 (64.3)*	*45 (35.7)*	*126 (100)*	

McNemar test.
ChatGPT, chat generative pretrained transformer; TMJ, temporomandibular joint.
*ChatGPT displays the results of ChatGPT in columns.
**Bard displays the results of Bard in rows.

medical and dental specialties. Primarily, these LLMs were initially developed as general-purpose interactive platforms and weren't specifically tailored to grasp medical literature nuances. Consequently, they lack the medical expertise and contextual comprehension necessary to navigate the intricate interplay between various medical conditions and treatments. Another significant consideration pertains to the training data. Most of the information integrated into these LLMs was derived from publicly accessible sources, potentially limiting access to information requiring paid journal subscriptions. This could be a limitation when addressing specific types of queries. Moreover, the LLMs may draw information from diverse sources, including non-medical ones, and may even retrieve data from outdated references, which may lead to erroneous responses. In addition, the core function of these LLMs revolves around predicting the subsequent words in a text sequence and constructing responses based on available data without assessing their accuracy. However, they lack inherent comprehension of the subjects, merely generating responses based on patterns, which might yield plausible yet factually incorrect or nonsensical answers, and this phenomenon is called "hallucination."[27] An example of hallucination can be seen in Figure 2 with both LLMs answering incorrectly and Bard further defending its reason of choice with confidence as if it's a fact. Such hallucinations can also be encountered in ChatGPT since there is a significant agreement between ChatGPT and Bard on correct and incorrect answers, which might be because they were equipped with a similar database. Consequently, cross-checking a question's answer between these LLMs does not increase the chance of getting the correct response. Therefore, both LLMs need to be developed to be used as reliable educational tools, as indicated by the studies on MCQ exams that reported ChatGPT achieving a passing score .[3,10,12,13,28]

Table 4. Chat Generative Pretrained Transformer's and Bard's Agreement on Correct/Incorrect Answers to Oral and Dentomaxillofacial Questions

		ChatGPT*			
		Incorrect	Correct	Total	
Questions	Bard**	n (%)	n (%)	n (%)	*P*
Oral medicine, oral diagnosis	Incorrect	11 (21.6)	10 (19.6)	*21 (41.2)*	
	Correct	7 (13.7)	23 (45.1)	*30 (58.8)*	.629
	Total	*18 (35.3)*	*33 (64.7)*	*51 (100)*	
Oral radiology	Incorrect	25 (34.7)	12 (16.7)	*37 (51.4)*	
	Correct	15 (20.8)	20 (27.8)	*35 (48.6)*	.701
	Total	*40 (55.6)*	*32 (44.4)*	*72 (100)*	
All questions	Incorrect	36 (29.3)	22 (17.9)	*58 (47.2)*	
	Correct	22 (17.9)	43 (35.0)	*65 (52.8)*	1.000
	Total	*58 (47.2)*	*65 (52.8)*	*123 (100)*	

McNemar test.
ChatGPT, chat generative pretrained transformer.
*ChatGPT displays the results of ChatGPT in columns.
**Bard displays the results of Bard in rows.

According to the results of this study, the correct response rate of LLMs decreases as Bloom's taxonomy level increases, though not significantly. Previous studies have also reported that ChatGPT exhibits diminished precision when addressing higher-order inquiries, indicating that even if it possesses knowledge, it cannot apply it critically.[1,6,9] In addition, there was a significant agreement between the LLMs on correct/incorrect answers to all questions according to Bloom's taxonomy level specified by the authors. This might be because these LLMs possess constraints in their capacity to accommodate specific question types or structures, as well as tasks related to constructing arguments and reasoning.[7]

Despite the constraints of LLMs, they are here to stay, and their potential influence on the medical and dental fields is enormous and cannot be ignored.[3,12,26] Therefore, they should be continuously evaluated in terms of advantages and challenges. Consequently, in this study, the performance of ChatGPT and Bard on the recognition of Bloom's taxonomy level and the correct response rate on questions related to subheadings of prosthodontics and oral and dentomaxillofacial radiology, the agreement of LLMs' on correct and incorrect answers, the effect of Bloom's taxonomy level on the

Table 5. The Effect of Lower/Higher-Order Classification, Specified by the Authors, on the Correct Response Rate of Chat Generative Pretrained Transformer and Bard

			Authors' Classification			
			Lower	Higher	Total	
			n (%)	n (%)	n (%)	*P*
ChatGPT	Prosthodontics	Incorrect	65 (62.5)	16 (72.7)	81 (643)	.506
		Correct	39 (37.5)	6 (27.3)	45 (35.7)	
	Oral and dentomaxillofacial radiology	Incorrect	42 (42.4)	16 (66.7)	58 (47.2)	.057
		Correct	57 (57.6)	8 (33.3)	65 (52.8)	
	Total	Incorrect	107 (52.7)	32 (69.6)	139 (55.8)	.056
		Correct	96 (47.3)	14 (30.4)	110 (44.2)	
Bard	Prosthodontics	Incorrect	59 (56.7)	18 (81.8)	77 (61.1)	.051
		Correct	45 (43.3)	4 (18.2)	49 (38.9)	
	Oral and dentomaxillofacial radiology	Incorrect	46 (46.5)	12 (50)	58 (47.2)	.934
		Correct	53 (53.5)	12 (50)	65 (52.8)	
	Total	Incorrect	105 (51.7)	30 (65.2)	135 (54.2)	.135
		Correct	98 (48.3)	16 (34.8)	114 (45.8)	

Yate's Continuity Correction
ChatGPT, chat generative pretrained transformer.

Table 6. Chat Generative Pretrained Transformer and Bard's Agreement on Correct/Incorrect Answers to All Questions According to the Authors' Lower/Higher-Order Classification

			ChatGPT*			
			Incorrect	Correct	Total	
		Bard**	n (%)	n (%)	n (%)	*P*
Prosthodontics	Lower	Incorrect	44 (42.3)	15 (14.4)	59 (56.7)	.405
		Correct	21 (202)	24 (23.1)	45 (43.3)	
		Total	65 (62.5)	39 (37.5)	104 (100)	
	Higher	Incorrect	15 (68.2)	3 (13.6)	18 (81.8)	.625
		Correct	1 (4.5)	3 (13.6)	4 (18.2)	
		Total	16 (72.7)	6 (27.3)	22 (100)	
Oral and dentomaxillofacial radiology	Lower	Incorrect	28 (28.3)	18 (18.2)	46 (46.5)	.597
		Correct	14 (14.1)	39 (39.4)	53 (53.5)	
		Total	42 (42.4)	57 (57.6)	99 (100)	
	Higher	Incorrect	8 (33.3)	4 (16.7)	12 (50)	.388
		Correct	8 (33.3)	4 (16.7)	12 (50)	
		Total	16 (66.7)	8 (33.3)	24 (100)	

McNemar test.
ChatGPT, chat generative pretrained transformer.
*ChatGPT displays the results of ChatGPT in columns.
**Bard displays the results of Bard in rows.

correct response rate of LLMs, and the LLMs' agreement on correct/incorrect answers to all questions according to Bloom's taxonomy level specified by the authors were investigated to assess their reliability in dental education. There is no similar study in the literature comparing ChatGPT's and Bard's performance on such parameters and revealing their strengths and weaknesses on MCQs about dental specialties, which is important, especially since the coronavirus 2019 pandemic because online exams became popular and MCQs are favored types of assessments due to their advantages. Regarding the results of this study, ChatGPT and Bard do not currently provide a sufficient correct response to allow substantial unfair advantage to students taking tests, and they are not reliable enough to be used as an educational tool. This inference, nevertheless, will inevitably change as LLMs undergo ongoing evolution. The advancement of these LLMs, propelled by refined training data and progressively intricate algorithms, foreshadows the emergence of more precise LLMs adept at producing contextually fitting answers. This progression, consequently, introduces new ethical predicaments about their implementation within educational contexts. Despite these possible disadvantages, the main point is to integrate LLMs as they advance into a broader learning strategy and supplement conventional educational resources such as textbooks and lectures.[12]

There are some limitations to this study. First, the result of this study belongs to the data from July 24 to 29, 2023, and as LLMs will likely continue to evolve rapidly, a future trial with the same items may yield different results. However, to pave the way for this rapid development by manufacturers, the shortcomings of LLMs for each subheading need to be clarified. Second, since the authors specialized in prosthodontics and oral dentomaxillofacial radiology, only questions of these specialties are evaluated, and these results cannot be generalized directly to other dental specialties but may set an example and lead the way to further studies. Third, the questions were asked only in Turkish as they were on the OSYM database because Turkish students would probably prefer to use Turkish, and if translated, there could be deviations from the original text. However, asking them in English could have increased the correct answer rate.[29] Fourth, since ÖSYM did not share statistical data on the correct answer rate of the test takers for each subheading, the results of LLMs could not be compared to human performance. Fifth, the questions with figures and tables were excluded since ChatGPT could not be integrated with multimodal input. In further studies, as these LLMs evolve rapidly, different kinds of questions with such input, different kinds of assessments like open-ended questions, other dental specialties, and various LLMs should be tested to be able to confidently integrate LLMs into dental education.

The agreement between both LLMs and authors on the recognition of Bloom's taxonomy level of MCQs was not significant. There was no statistically significant difference between ChatGPT and Bard, related to the correct response rate of MCQs on prosthodontics (35.7% and 38.9%, respectively) and oral and dentomaxillofacial radiology (52.8% for both LLMs), and there was a significant agreement between ChatGPT and Bard on correct and incorrect answers. As Bloom's taxonomy level increased, the correct response rate of LLMs decreased, though not significantly.

As a result, these LLMs are not yet reliable educational tools but can be used as a supplement to traditional educational methods as they evolve. They can even be integrated into the dental education curriculum after sufficient development, but dental academicians should be aware of their strengths and weaknesses to prepare assessments accordingly and to guide their students in self-learning strategies.

Ethics Committee Approval: This study does not require ethics committee approval since it does not involve any living subjects or personal data.

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Evaluation of the Effect of Dental Technicians' Ceramic Application Experience on Metal–Ceramic Bonding: A Pilot Study

Diş Teknisyenlerinin Seramik Uygulama Deneyiminin Metal Seramik Bağlanmasına Etkisinin Değerlendirilmesi: Bir Pilot Çalışma

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ABSTRACT

Objective: The aim of this study was to evaluate the effect of dental technicians' experience on the shear bond strength (SBS) of ceramic fused to metal restorations.

Methods: Totally 32 casting cobalt–chromium (Co-Cr) disc-shaped (r = 10 mm diameter, h = 1 mm height) specimens were prepared for 2 experimental groups [group 1: untrained dental technician, group 2: conversant dental technician] (n = 16 per group). Ceramic was applied to the disc specimens (h = 4 mm height, r = 6 mm diameter), and their SBS was measured with a universal testing device. Results were statistically analyzed using the Student's t-test (α = .05).

Results: According to the Student's t-test, no statistically significant differences were seen between the 2 groups (P = .270).

Conclusion: The experience of the dental technicians did not affect the bond strength of casting Cr-Co alloys.

Keywords: Experience, technician, metal–ceramic bonding

ÖZ

Amaç: Bu çalışmanın amacı teknisyen deneyiminin metal destekli seramik restorasyonların makaslama bağlanma direncine (shear bond strength-SBS) etkisinin olup olmadığının araştırılmasıdır.

Yöntemler: 32 tane döküm Co-Cr disk (10 mm çapında, 1mm kalınlığında) şeklinde örnek iki ayrı çalışma grubu [Grup 1: Deneyimsiz diş teknisyeni (Untrained dental technician-UDT), Grup 2: Deneyimli diş teknisyeni (Conversant dental technician-CDT)] (n = 16 her bir grup için) hazırlandı. Örneklere seramik uygulaması (4 mm yüksekliğinde, 6 mm çapında) yapıldı ve SBS üniversal bir test cihazı ile ölçüldü. Sonuçlar istatistiksel olarak Student t-test ile analiz edildi (α = .05). Bulgular: Deney grupları arasında istatistiksel olarak anlamlı bir sonuç bulunmamıştır (P =.270).

Sonuç: Diş teknisyeninin deneyimli olup olmamasının döküm Co-Cr alaşımlarının bağlanma direncine etkisi görülmemiştir.

Anahtar kelimeler: Deneyim, teknisyen, metal-seramik bağlanması

INTRODUCTION

Nowadays, the fixed prosthetic dentures (FPD) have a variety of material options for different indications. Ceramics fused to different substructure metals, zirconia, full ceramics, and monolithic zirconia blocks are used for fixed prosthetic restorations.[1,2] Although all-ceramic crowns are gaining popularity, approximately 80% of FPD are ceramic-fused-to-metal restorations.[1,3] The most important preference factor of the metal–ceramic restorations is long-term clinical success, and this factor is influenced by case selection, tooth preparation, impression, lab facilities, cementation, and practitioner age.[4,5]

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The amount of support that the metal framework will provide to the ceramic is directly proportional to the quality of the metal–ceramic bond.[3] The bonding of porcelain to metal alloy is vital for the success of ceramic-fused-to-metal restorations, especially under the rigors of oral function.[2] Despite the advantages of metal–ceramic crowns/bridges, the bonding problems between metal and ceramic cause very high rates of failure.[2,6] These failures occur due to the incompatibility of the coefficient of thermal expansion between the metal and veneer ceramics, the surface properties of metal frameworks (surface roughness, wetting capability), improperly designed frameworks, inappropriate firing conditions, and other factors.[2,4,6-8] Therefore, quite a lot of research has been done to make this bonding stronger.

The application of ceramic to the metal frameworks includes a series of technical procedures according to the manufacturing instructions. To mask the base metal color, first opaque ceramic is applied to the framework and then the dentin ceramic is applied by the technicians.[9,10] These steps are applied by using brushes. Therefore, the thickness of the opaque and dentin layers and the aesthetics results of the restorations depend on the technicians' expertise and skill in his area.[9-11] Dental technicians put a great deal of effort into designing and manufacturing prosthetic restorations. Although the share of technicians in scientific studies is ignored, it is advocated to take this into consideration.[9-11] It is very important to inform the technician about the biological and clinical factors to be considered in the design and production of the prosthesis, and this communication has a great impact on the success of the prosthesis.[12] Another important factor is the skill of the technician.[9] Today, many studies have been carried out on the properties of the materials used and the evaluation of the effect of production methods on the success of prostheses.[13-15] However, there are limited studies on the evaluation of parameters related to technicians, who have the largest share in the production of prosthesis.

The aim of the present study was to evaluate the effect of dental technicians, who are untrained and conversant, on the bonding values between the ceramic and casting cobalt–chromium (Co-Cr) alloy. The null hypothesis was that the bond strength of the specimens produced by the conversant dental technicians would be higher than the untrained group.

MATERIAL AND METHODS

In total, 32 casting Co-Cr alloy disc (r = 10 mm diameter, h = 1 mm height) specimens were prepared for 2 experimental groups [group 1: untrained dental technician (UDT), group 2: conversant dental technician (CDT)] (n = 16) to analyze the shear bond strength (SBS).

Casting disc specimens were produced with a specially designed aluminum mold to reach a standard dimension. To obtain the negative spaces of this mold for preparing wax patterns (Kronenwachs; Bego, Bremen, Germany) a liquid silicone (Platsil73-29; Polytek Development Corp) was used.[4] These wax patterns were invested with phosphate-bonded investment material (Bellavest SH, Bego, Bremen, Germany). Following wax elimination, 32 specimens were cast from Co-Cr alloy (Remanium® star, CL, Dentaurum, Ispringen, Germany) according to the manufacturers' instructions by an induction-casting machine (Fornax, Bego, Breman, Germany). The castings were divested, and the casting defects were removed with a low-speed hand piece (10 000 rpm) by using a laboratory tungsten bur. Following this, the specimens were airborne-particle abraded with 110-µm Al_2O_3 particles (Korax, Bego, Bremen, Germany), at a pressure of 0.5 MPa applied for 10 seconds at a distance of 2 cm. Then the specimens were ultrasonically (Biosonic JR, Whaledent Int. NY, USA) cleaned in distilled water.

Before the feldspathic ceramic application, the casting specimens were divided into 2 groups (n = 16) and distributed to the technicians. One of the dental technicians (CDT) was senior in his work and had been studying in this area for about 12 years. The other technician had just graduated from the technician school and was inexperienced in his work. Two of the technicians were informed about how to use the specified molds for ceramic application. Then the feldspathic ceramic was applied to the disc specimens by the technicians according to the manufacturer's instructions. During the ceramic application process, the technicians were free to choose the time that they needed to apply the ceramic to the specimens. First, a layer of opaque ceramic (Ceramco3 Base Pasta, Dentsply, USA) was applied, and then the second layer of opaque (Ceramco3 Pasta Opaque, Dentsply, USA) was applied on the first layer of opaque. Subsequently, dentin ceramic (Ceramco3 Dentin, Dentsply, USA) was applied by using liquid silicone molds[4] (4 mm height and 6 mm diameter), and firing was performed in a porcelain furnace (Programat P300 Ivoclar Vivadent AG, Liechtenstein). The feldspathic ceramic firing temperature procedures are seen in Table 1.

After ceramic application was completed, the specimens were subjected to the aging procedure. This procedure consisted of 5500 cycles of alternate water-bath immersion at 4°C and 60°C at a dwell time of 1 minute each temperature.

The specimens were embedded in auto-polymerized acrylic resin (Simplex Rapid Powder, Kemdent, Swindon) using silicone molds (12 x 12 x 12 mm^3). Shear force was applied to the metal–ceramic interface in a universal testing machine (Lloyd Instruments LRX) with a shearing blade at a crosshead speed of 1 mm/min until failure occurred. Peak force values at failure were recorded in Newton (N) and divided by the surface area to obtain the bond strength values (MPa = N/mm^2).

After the SBS test, the debonding surfaces of the 2 specimen groups were examined by 2 operators to determine the failure modes. Specimens were then grouped into 3 categories: adhesive (no ceramic left on the alloy surface), cohesive (no alloy

Table 1. The Feldspathic Ceramic Fiiring Temperature Chart

°C	Time (minutes)			Time (minutes)		Vacuum	Set Temperature		Temperature		
Program Description	Dry	Preheat	Vacuum	Hold	Cool	Set Point (in Hg)	Idle	High Temperature	Vacuum Start	Vacuum Stop	Heat Rate °C/min
1. Pasta opaque	3	3	0	0	0	29	500	975	500	975	100
2. Powder opaque	5	3	0	0	0	29	650	970	650	970	70
1. Dentin	5	5	0	0	0	29	650	950	650	950	55
2. Dentin	5	5	0	0	0	29	650	950	650	950	55

surface, failure occurred just within the opaque ceramic), and mixed (partially ceramic left on the alloy surface) failure.

Statistical analysis was performed using Statistical Package for the Social Sciences Statistics version 25.0 software program (IBM Corp.; Armonk, NY, USA). The results of the SBS were statistically analyzed with a Student *t*-test after examining the data by the Shapiro–Wilk test for normality ($\alpha = .05$).

RESULTS

The descriptive statistics for the SBS are presented in Table 2. The results of the Student *t*-test comparing the 2 experimental groups ($t = -1.132$) indicated that there were no statistically significant difference between the groups ($P = .270$). The mean SBS of the UDT group was 17.72 ± 2.61 MPa and that of the CDT group was 19.37 ± 5.244 MPa. The distribution of failure types of the experimental groups is shown in Figure 1.

DISCUSSION

The aim of the present study was to evaluate the effect of dental technicians, who are untrained and conversant, on the bonding values between the ceramic and casting Cr-Co alloy. The null hypothesis that the bond strength of the specimens produced by the conversant dental technicians would be higher than that of the untrained group was rejected. There was no statistically significant difference in SBS between the untrained and conversant dental technician groups.

To improve the long-term success of the FPD, the researchers evaluated the manufacturing methods, variety of ceramic materials, different surface treatments, different firing conditions, etc.[1,13,15-17] However, there is limited research on the effect of experience of the dental technician on the metal–ceramic bond of the FPD, as the application of the ceramic to the metal framework mostly depends on the manipulation skill of the dental technician. Pişkin et al[9] investigated the effect of different dental technicians on the thickness of the opaque layer and color of the ceramic. They reported that the opaque layer thickness and the color of the ceramic had been significantly effected from different dental technicians.[9] In the present study, all steps of the specimens' preparation were performed by another conversant technician up to the ceramic application stage to reach a standard. Then the ceramic was applied to the specimens by the untrained and conversant dental technicians. The ceramic was applied to the specimens by these technicians in 4 steps; 2 opaque layers and 2 dentin layers. In the present study, as mentioned in the null hypothesis, SBS values of the CDT group were expected to be higher than the UDT group. However, although the mean SBS value (19.37 ± 5.24 MPa) of the CDT group was higher than the UDT (17.72 ± 2.61 MPa) group, statistically no significant differences were found between the groups. DDuring the ceramic application period no time limit was imposed to technicians. Therefore it is considering that the UDT group technician was able to take sufficient care in his specimens' preparation steps. When we evaluate the box plot (Figure 2), the SBS values for the UDT group demonstrate more normal distribution than the CTD group. The range between the minimum and maximum SBS values of the UDT group was smaller than the CTD group. This situation may be the result of that the conversant technician may be work more imprecisely on specimens than untrained technician due to relying on his laboratory experience.

The adhesion strength between metal and ceramic can be tested with different testing methods such as shear strength test, biaxial flexural test, 3-point bending test, and 4-point bending test.[13,16] Three-point bending test is the grade of International Organization for Standardization (9693) standard; however, the SBS test is used in this study due to the easy preparation of the specimens. In the present study, SBS test specimen design was prepared as in the previous studies,[4,13,18] and the specimen size was determined to tolerate the nonhomogeneous stress distribution of the SBS test.

Values of SBS in the 2 study groups were lower than 25 MPa in this study. This value is the accepted bond strength value between metal and ceramic by the International Standard (ISO9693).[1,15,17,18] The lower values of bond strength may be explained by the

Table 2. Descriptive Statistics (in MPa) and Results of the Student *t*-test Comparisons of the Shear Bond Strength of Metal–Ceramic Bond Between the Untrained Dental Technician and Conversant Dental Technician

Group Tested	n	Mean (MPa)	SD	Range
UDT	16	17.72	2.61	13.74-22.05
CDT	16	19.37	5.24	12.02-27.72

t-test = −1.132; $P = .270$.
CDT, conversant dental technician; MPa, megapascal; UDT, untrained dental technician.

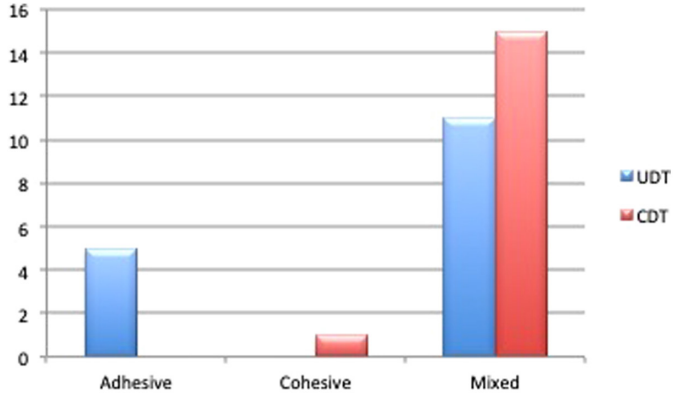

Figure 1. Distribution of failure modes for experimental groups analyzed after shear bond strength test test. UDT, untrained dental technician; CDT, conversant dental technician.

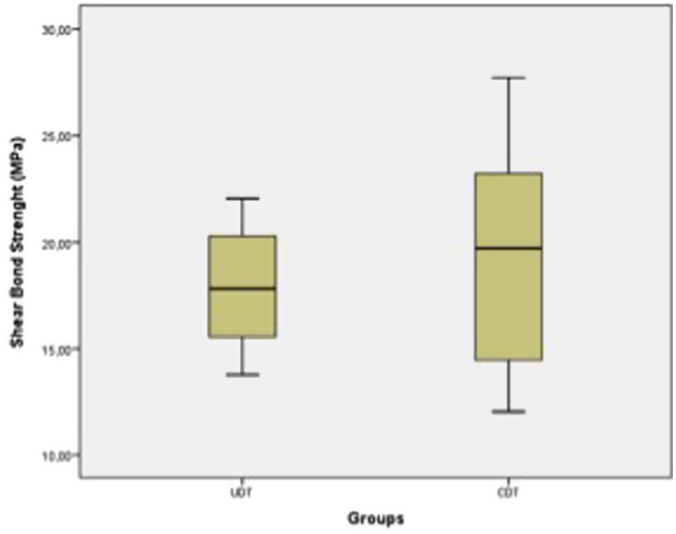

Figure 2. Shear bond strength of untrained dental technician and conversant dental technician experimental groups.

application of aging process. As mentioned in the previous studies, the aging processes cause a decrease in metal–ceramic bonding.[17,18,19] Trindade et al[20] reported that the temperature changes during aging procedure cause stress between metal and ceramic due to the different coefficient of thermal expansion values of the materials, and this situation weakens the SBS of the specimens.

In the present study, there were seen 5 adhesive failures in the UDT specimen group, whereas there were none in the CDT group. Additionally, nearly both of the other failure types of the 2 groups were mixed failures. During the ceramic application processes, the application of the opaque layer depends on the brush skill of the dental technician.[9,10] The large number of adhesive failures of the UDT group may be due to the brushing skills of the untrained technician. As a limitation of this study, the opaque layer thicknesses of the specimen groups were not measured before the dentin application process. Xu et al[21] had reported that opaque layer thicknesses have an influence on the bond strength of metal–ceramic restorations. Therefore, the UDT technician's opaque layer application may have been weaker than the CDT technician's opaque layer application. This may be the cause of the large number of adhesive failures that were seen in the UDT group.

Based on the results of the present study, as dental technician experience did not affect the metal–ceramic bonding, the dental laboratories may work with the newly graduated dental technicians. However, time limitations and morphology of the restorations should be taken into account, as these are skills that can be developed over time. Another limitation of this study is the number of technicians. Working with more technicians would demonstrate a more general result.

The results of this in vitro study reached the following conclusions. The experience of the technicians was not affected by the bond strength of casting Co-Cr alloys. The dental laboratories can give a chance to untrained technicians for restoring metal ceramic restorations without time limits.

Ethics Committee Approval: As it was an in-vitro study, the ethics committee approval was not considered necessary.

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Evaluation of Oral Health Awareness and Dental Fear Levels of Dentistry Students

Diş Hekimliği Öğrencilerinin Ağız Sağlığı Bilinci ve Dental Korku Seviyelerinin Değerlendirilmesi

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ABSTRACT

Objective: The objective of this study was to compare the oral health awareness and fear levels of students enrolled in the Faculty of Dentistry at Gaziantep University, based on their education and training program.

Methods: The current study involved 381 participants, comprising 247 females and 134 males, from the Faculty of Dentistry at Gaziantep University. The Hiroshima University Dental Behavior Inventory and Dental Fear Scale, consisting of 20 questions each, were administered to the students, and their responses were recorded. The data were analyzed using Kruskal–Wallis and all pairwise tests, and statistical significance was determined at a level of $P < .05$.

Results: A significant difference was found between first-fourth, second-fourth, and second-third grades when compared in terms of the 17th question on the Dental Fear Scale ($P < .05$). According to Hiroshima University Dental Behavior Inventory, there was a significant difference between the general Hiroshima University Dental Behavior Inventory scores between the fifth grade and all other grades ($P < .05$).

Conclusion: The students who participated in the study displayed high oral health attitude and behavior scores. Furthermore, the educational process played a positive role in the development of clinical students, as they demonstrated improved dental fear and individual oral health attitudes and behaviors compared to their preclinical counterparts.

Keywords: Dental fear scale, dental student, hiroshima university dental behavior inventory

ÖZ

Amaç: Bu çalışmada Gaziantep Üniversitesi Diş Hekimliği Fakültesi öğrencilerinin ağız sağlığı bilincinin ve korku seviyelerinin eğitim-öğretim programına göre karşılaştırmalı değerlendirilmesi amaçlanmıştır.

Yöntemler: Çalışmaya Gaziantep Üniversitesi Diş Hekimliği Fakültesi'nden 247'si kız 134'ü erkek olmak üzere 381 öğrenci dâhil edilmiştir. Öğrencilerin 20 sorudan oluşan Hiroşima Üniversitesi Dental Davranış Envanteri (HU-DBI) ile Dental Korku Skalası (DKS) anketini cevaplandırmaları istendi ve veriler kaydedildi. İstatistiksel analiz için Kruskal Wallis ve All pairwise testleri kullanıldı. Anlamlılık $P < .05$ düzeyinde değerlendirilmiştir.

Bulgular: Dental Korku Skalası 17. soru açısından karşılaştırıldığında 1. ile 4., 2. ile 4. ve 2. ile 3. sınıflar arası anlamlı fark bulunmuştur ($p < 0.05$), Hiroşima Üniversite Dental Davranış Envanteri'ne göre ise 5. sınıf ile diğer tüm sınıflar arası genel Hiroşima Üniversitesi Dental Davranış Envanteri skorları arasında anlamlı fark tespit edilmiştir ($P < .05$).

Sonuç: Araştırmaya katılan öğrencilerin ağız sağlığı tutum ve davranışları Hiroşima Üniversitesi Dental Davranış Envanteri skorları bazında genel olarak yüksek bulundu. Öğrencilerin eğitim aldıkları süreç göz önünde bulundurulduğunda klinik öğrencileri preklinik öğrencilerinden hem dental korku hem de bireysel ağız sağlığı tutum ve davranışları açısından olumlu yönde gelişmektedir.

Anahtar Kelimeler: Dental korku skalası, diş hekimliği öğrencileri, hiroşima üniversitesi dental davranış envanteri

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INTRODUCTION

Dental caries, which harbors various microorganisms, is one of the most common infectious diseases affecting people worldwide.[1] The prevention of diseases related to oral health, which is of utmost importance for overall health, will become feasible through the implementation of preventive measures. The primary responsibility for this lies with dentists and dental students, who are charged with raising awareness about the importance of oral health. Recent studies have indicated that the level of knowledge among dental students regarding oral health has improved significantly.[2]

It has been observed that thoughts and behaviors related to oral health vary in different countries, different cultures, and even among students in different classes studying in the same faculty.[3-5] The Hiroshima University Dental Behavioral Inventory (HU-DBI) was developed by Dr. Makoto Kawamura in 1988 as a tool for assessing individuals' oral and dental health and self-care habits due to challenges in conducting comparisons across international populations.[6] The HU-DBI is a questionnaire utilized to assess the oral health knowledge, attitudes, and behaviors of dental students and professionals. The HU-DBI comprises 20 items that encompass various aspects of oral health, such as tooth brushing frequency, dental visits, diet, smoking, and self-perception. The questionnaire employs a binary response format (agree/disagree) and boasts a total score ranging from 0 to 19, with higher scores indicating more favorable oral health attitudes and behaviors.[7,8] The HU-DBI is an effective and reliable tool for assessing the oral health status and needs of dental students and professionals. It can also be used to evaluate the impact of oral health education programs and identify areas for improvement.[9] The HU-DBI serves as a valuable tool for dental educators and researchers to comprehend the factors that impact the oral health behaviors of their students and peers and to devise effective strategies to enhance oral health awareness and practice.

Dental fear is a state of anxiety that develops due to frequently experienced emotional factors. Although dental treatments are more comfortable with advancing technologies, the fear felt by patients continues.[10] The Dental Fear Scale (DFS), developed by Kleinknecht,[11] utilizes a series of questions to assess an individual's response to dental treatment. Questions 1 and 2 evaluate the patient's reaction to dental care, while questions 3 through 7 assess the systemic symptoms experienced during dental interventions. From question 8 onward, the scale determines the level of fear of dentists based on the patient's response to various dental applications. The validity–reliability test of this scale in our language was conducted by Inanc et al.[12]

Upon review of the existing literature, the relationship between oral health awareness and dental anxiety or anxiety–fear scales in dental students was generally examined, but no publication was found that evaluated the relationship between oral health awareness and dental fear. The aim of this study was to evaluate the oral health attitudes and behaviors and dental fear levels of dental students according to the differences in the years of education program using the HU-DBI and DFS.

The null hypotheses were as follows;

i. There are no differences among all students in grades in terms of HU-DBI.
ii. There are no differences among all students in grades in terms of DFS.

MATERIAL AND METHODS

A total of 381 volunteers, 247 female and 134 male, from the first, second, third, fourth, and fifth grade students of the Faculty of Dentistry of Gaziantep University who are continuing their education and training in 2022-2023, were included in the study. Gaziantep University Clinical Research Ethics Committee applied for this study, and ethics committee approval was obtained with decision number 2023/55. The STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist was used to report on the methodological quality of observational studies. The questionnaires were administered to the students on a voluntary basis at the end of the class period in order not to interfere with their class schedules. Prior to their involvement in the study, informed consent forms were obtained from the participants, and no personal identifying information was collected from the survey respondents. The inclusion criteria were that the students answered all questions completely and indicated the year of the program they were studying. Students who did not want to participate in the study are excluded.

Sample Analysis

Using Raosoft software (Raosoft Inc., Seattle, Wash, USA), the sample size was determined as 380 with a 5% margin of error at a 95% CI and a population size of 35 000. The current study was conducted with 381 volunteers.

Hiroshima Dental Behavior Inventory

It is a questionnaire consisting of 20 questions, to which answers are given as agree/disagree. In this study, the translated version of the 20 HU-DBI questions from English to Turkish was used.[13] The validity–reliability test of the questionnaire was found to be 100% by Dogan et al.[13] In the numerical evaluation of the HU-DBI questionnaire results, the students' scores were calculated by giving 1 point to those who answered agree and 0 point to those who answered disagree to questions 4, 9, 11, 12, 16, 19; 1 point to those who answered disagree and 0 point to those who answered agree to questions 2, 6, 8, 10, 14, 15. The maximum HU-DBI value that can be obtained with this system is 12, and there is a positive correlation between the size of the value obtained and oral health behavior. The questions of this scale are shown in Figure 1.

Dental Fear Scale

In 1973, Kleinknecht et al[11] introduced the DFS, a scale used to measure the level of avoidance of visiting the dentist, the impact of fear on the body, and the level of fear of dental practices. This scale, which aims to show the level of avoidance of going to the dentist, the effect of the fear on the body, and the level of fear of dentist–dentistry practices, includes 20 questions in total, and the answers to the questions in the scale are evaluated with scores between 1 and 5 (almost never answer "1" point, very little answer "2" point, a little answer "3" point, very much answer "4" point, very much answer "5" point). The maximum score that can be obtained from the scale is 100, while the minimum score is 20. With the calculations made, 80 points and above are considered as individuals with extremely high fear level; 60-80 points as individuals with high fear level, 40-60 points as individuals with moderate fear level, and 40 points and below as individuals with low fear level. The questions of this scale are shown in Figure 2.

Statistical Analysis

Statistical Package for the Social Sciences version 22.0 software (IBM Corp.; Armonk, NY, USA) program was used for statistical analysis of the findings obtained in the study. Kruskal–Wallis test

	Agree	Disagree
I don't worry much about visiting the dentist		
My gums tend to bleed when I brush my teeth		
I worry about the color of my teeth		
I have noticed some white deposits on my teeth		
I use a child sized toothbrush		
I think that I cannot help having false teeth when I am old		
I am bothered by the color of my gums		
I think my teeth are getting worse despite my daily brushing		
I brush each of my teeth carefully		
I have never been professionally taught how to brush		
I think I can clean my teeth well without using toothpaste		
I often check my teeth in a mirror after brushing		
I worry about having bad breath		
It is impossible to prevent gum disease with tooth brushing alone		
I put off going to the dentist until I have a toothache		
I have used a dye to see how clean my teeth are		
I use a toothbrush which has hard bristles		
I don't feel I've brushed well unless I brush with strong strokes		
I feel I sometimes take too much time to brush my teeth		
I have had my dentist tell me that I brush very well		

Figure 1. Hiroshima university dental behavior inventory.

was used for intergroup comparisons. Mann– Whitney *U*-test was used to determine in which group there was a statistical difference. Statistical significance level of .05 was accepted.

RESULTS

Hiroshima University Dental Behavioral Inventory Results

Table 1 displays the mean and standard deviation values of the groups under analysis. A significant discrepancy was observed in the HU-DBI evaluation between the groups ($P < .05$). Furthermore, a statistically significant difference was found between grade 5 and grades 1, 2, 3, and 4 ($P = .001$). Specifically, the highest value was obtained from fifth-grade students, with a mean score of 6.87 and a standard deviation of 1.47.

Dental Fear Scale Results

Table 2 displays the mean and standard deviation values for each group in terms of DFS. When evaluated in terms of DFS, no statistically significant difference was found between the groups ($P > .05$). The highest value was obtained from second grade students (41.89 ± 2.18); the lowest value was obtained from fourth grade students (39.73 ± 1.81). According to these values, the student

	1	2	3	4	5
1- Has fear of dental work ever caused you to put off making an appointment?					
2- Has fear of dental work ever caused you to cancel or not appear for an appointment?					
3- When having dental work done; my muscle become tense					
4- When having dental work done; my breathing rate increases					
5- When having dental work done; I perspire					
6- When having dental work done; I feel nauseated and sick to my stomach					
7- When having dental work done; my heart beats faster					
8- Making an appointment for dentistry					
9- Approaching the dentist's office					
10- Sitting in the waiting room					
11- Being seated in the dental chair					
12- The smell of the dentist's office					
13- Seeing the dentist walk in					
14- Seeing the anesthetic needle					
15- Feeling the needle injected					
16- Seeing the drill					
17- Hearing the drill					
18- Feeling the vibrations of the drill					
19- Having your teeth cleaned					
20- All things considered, how fearful are you of having dental work done?					

Figure 2. Dental fear scale.

Table 1. Mean and Standard Deviation Values of the Groups for Hiroshima University Dental Behavioral Inventory (Mean ± SD)

Groups	(Mean ± SD)
Group 1 (grade 1)	5.90 ± 1.68[a]
Group 2 (grade 2)	5.78 ± 1.65[a]
Group 3 (grade 3)	5.75 ± 1.83[a]
Group 4 (grade 4)	6.44 ± 1.61[a]
Group 5 (grade 5)	6.87 ± 1.47[b]

Different lowercase letters indicate statistically significant differences ($P < .05$). Significance values have been adjusted using the Kruskal–Wallis.

groups with the least fear belong to the fourth and fifth grades. In this case, fourth and fifth grades were determined as low fear level, while first, second, and third grades were determined to have moderate fear level.

A statistically significant difference was found between the first and fourth ($P = .032$), second and fourth ($P = .006$), and second and third ($P = .029$) grades according to the 17th question in this scale, "I feel fear and tension when I hear the sound of rotating instruments" ($P = .028$).

DISCUSSION

Dental schools exert a direct or indirect impact on the attitudes of students towards oral health. The high level of awareness displayed by dental students towards oral health has a significant impact on their approach to patient education, and they play a crucial role in spreading oral health awareness among the general population.[2,12] The first null hypothesis was partly rejected, and the second hypothesis was accepted in the present study according to outcomes.

In a 2008 study, the HU-DBI questionnaire was administered to students from 2 different dental schools, and the mean score was 6.59 ± 2.0.[13] The HU-DBI score obtained in our study was 6.09 ± 1.70. These findings indicate that the value obtained in the present study is lower than the mean value reported by Başak et al.[13] It can be explained by the presence of students receiving distance education due to the coronavirus disease 2019 pandemic and the fact that this education is not as effective as face-to-face education.

It is widely documented in the literature that dental health attitudes and behaviors tend to become more favorable and exhibit improvement with increasing levels of education.[14-17] In our study, the highest HU-DBI scores were obtained in the fourth (6.44) and fifth (6.84) grades. This score is higher than the values obtained from grades 1, 2, and 3. Peker et al[18] examined oral health attitudes and behaviors according to years of education and found that the HU-DBI score of fourth and fifth grade students was significantly higher than that of first, second, and third grade students. Our investigation revealed that the statistically insignificant value for fourth graders was found to be significantly higher for fifth graders. With regards to the aforementioned study by Peker et al,[18] our current research shares similarities in terms of its focus on the clinical education of dentistry students. It is believed that the commencement of clinical education from the 4th grade and exposure to patient interactions for Gaziantep University dentistry students may have contributed to the higher scores attained by clinical students compared to preclinical students.

Table 2. Mean and Standard Deviation Values of the Groups for Dental Fear Scale (Mean ± SD)

Groups	(Mean± SD)
Group 1 (grade 1)	41.89 ± 2.18[a]
Group 2 (grade 2)	43.90 ± 2.30[a]
Group 3 (grade 3)	41.02 ± 1.88[a]
Group 4 (grade 4)	39.73 ± 1.81[a]
Group 5 (grade 5)	39.97 ± 1.92[a]

Different lowercase letters indicate statistically significant differences ($P < .05$). Significance values have been adjusted using the Kruskal–Wallis.

Camgoz et al[19] reported that half of the volunteers disagreed with question 10 of the HU-DBI questionnaire (I have never been taught professionally how to brush), and similar results were observed in our study. However, in the same study, it was reported that question 15 (I put off going to the dentist until I have toothache) was similar to the answers to question 10.[19] In our study, the majority of the students answered "disagree" in this question, which is not compatible with this aspect. It is worth noting that the study in the literature did not only include students from the faculty of dentistry but also participants from other faculties. This may explain the difference between the 2 studies.

There are many studies in the literature examining the relationship between oral health attitudes and behaviors and dental students in different countries.[2,3,16,20] When the score obtained in our study (6.09) was compared with HU-DBI surveys conducted in other countries, it was found to be higher than the results in India (6.06)[21] and China (5.07),[22] but lower than those in the UK (7.33),[22] Greece (6.86)[9] and Japan (7.40).[9] It is encouraging that the values obtained are higher than those of some countries, but it is notable that they are lower than those of European countries, which suggests that there is a need to enhance attitudes, behaviors, and awareness regarding oral health.

The fear of dentistry and the resulting avoidance of dental care are significant issues that affect both dental health and overall health. Despite the ever-increasing technological advances in the dental field, fear of the dentist or dental treatment still persists. A national survey in the United States found that 9% of those who do not go to the dentist cite fear as the main reason for not going.[23] A different study found that the incidence of dental treatment fear was 49.4% and this percentage was much higher than that of animals (39%), height (30.7%), and depth (13.2%). A report was conducted on the fact that many people were found to have much more fear of dental treatment than expected.[24]

The planned treatment and the procedures performed during the treatment period are believed to have a significant impact on dental anxiety. According to Wong and Lytle,[25] root canal treatment and tooth extraction are the dental procedures most feared by patients. In their study, Kleinknecht et al[11] stated that the situations in which the fear experienced during dental treatment occurs in response should be specificized and emphasized that this situation is important in terms of guiding dentists and taking precautions by the practitioner. In addition, in this study, it was reported that the stimuli that elicited the greatest fear response were anesthetic needle and rotary instrument.[11] This explains the significant difference between the groups in the statistical analysis conducted for the question "I feel fear and tension when I hear the sound of the aerotor (rotating device)" in the DFS.

Erten et al[26] found that dental fear was higher in people who had never been to a dentist before. The finding that the DFS value of clinical students was lower than that of preclinical students with no clinical experience without a significant difference was also supported by this study. At Gaziantep University's Faculty

of Dentistry, students start attending clinical training from the fourth grade, which explains why their anxiety levels are generally lower than those of preclinical students. In summary, dental students' dental fear levels decreased in relation to the period of dental education.

To the best of our knowledge, there is no study in literature evaluating HU-DBI and DFS values. In our study, there were limitations, including not conducting studies with more than one university and more participants.

The oral health attitude and behavior scores of the students participating in the study were generally high. In terms of dental fear, they were either on the low fear or moderate fear scale, and no high or very high fear values were obtained.

In light of the students' year of education and clinical experience, it was observed that clinical students demonstrated positive development in both dental fear and individual oral health attitudes and behaviors, as compared to their preclinical counterparts.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Gaziantep University Clinical Research Ethics Committee (Date: 12.04.2023, Number: 2023/55).

Informed Consent: Prior to their involvement in the study, informed consent forms were obtained from the participants, and no personal identifying information was collected from the survey respondents.

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Relationship Between Health Literacy Level and Gingival Health

Sağlık Okuryazarlığı Düzeyi ile Diş Eti Sağlığı Arasındaki İlişki

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ABSTRACT

Objective: Oral and dental health is an inseparable component of general health. In this study, it was aimed to assess the relationship between health literacy level and dental and gum health of individuals.

Methods: This study was conducted with 342 randomly selected participants at 3 institutions with the highest patient density. Initially, dental and gum health of the participants were evaluated. Turkey Health Literacy Scale-32 (TSOY-32) was used to evaluate the health literacy levels of the participants. The data were analyzed using the Statistical Package for the Social Sciences Statistics, version 22.0 software.

Results: The average TSOY-32 score of the participants was determined as 22.85 ± 8, ranging from 2.60 to 41.67. The average scores of the participants selected from the Faculty of Dentistry, the Oral and Dental Health Center, and the Dental Polyclinics of Mareşal Çakmak State Hospital were 25.12 ± 7.8, 21.11 ± 8.1, and 22.31 ± 7.7, respectively. The TSOY-32 mean score was calculated as 25.36 for the participants with 1 and 2 tooth brushing frequencies per day and 17.66 for the individuals who brush their teeth only when they remember ($P < .05$). The gingival and Community Periodontal Index of Treatment Needs index values were lower in participants with high health literacy levels ($P < .05$).

Conclusion: It has been determined that individuals with high health literacy levels pay more attention to oral hygiene habits; therefore, their teeth and gums are healthier.

Keywords: Dental health surveys, gingival index, health literacy, oral hygiene, periodontal index, public health

ÖZ

Amaç: Ağız ve diş sağlığı genel sağlığın ayrılmaz bir bileşenidir. Bu çalışmada bireylerin sağlık okuryazarlığı düzeyi ile diş ve diş eti sağlığı arasındaki ilişkinin değerlendirilmesi amaçlandı.

Yöntemler: Bu çalışma, hasta yoğunluğunun en fazla olduğu üç kurumda rastgele seçilmiş 342 katılımcı ile gerçekleştirildi. Öncelikle katılımcıların diş ve diş eti sağlıkları değerlendirildi. Katılımcıların sağlık okuryazarlığı düzeylerini değerlendirmek amacıyla Türkiye Sağlık Okuryazarlığı Ölçeği-32 (TSOY-32) kullanıldı. Veriler SPSS versiyon 22.0 programı kullanılarak analiz edildi.

Bulgular: Katılımcıların ortalama TSOY-32 puanı 22,85±8 olup 2,60 ile 41,67 arasında değişmektedir. Diş Hekimliği Fakültesi, Ağız ve Diş Sağlığı Merkezi ve Mareşal Çakmak Devlet Hastanesi Diş Polikliniklerinden seçilen katılımcıların ortalama puanları sırasıyla 25,12±7,8, 21,11±8,1 ve 22,31±7,7 olarak gerçekleşti. Günde bir ve iki diş fırçalama sıklığına sahip katılımcıların TSOY-32 puanı ortalaması 25,36, dişlerini yalnızca hatırladığı zaman fırçalayan bireylerin ise 17,66 puan olarak hesaplandı ($P < 0,05$). Sağlık okuryazarlığı düzeyi yüksek olan katılımcılarda diş eti ve CPITN indeks değerleri daha düşüktü ($P < 0,05$).

Sonuç: Sağlık okuryazarlığı düzeyi yüksek bireylerin ağız hijyeni alışkanlıklarına daha fazla dikkat ettikleri, dolayısıyla diş ve diş eti sağlıklarının daha iyi olduğu belirlendi.

Anahtar Kelimeler: Diş sağlığı araştırmaları, diş eti indeksi, sağlık okuryazarlığı, ağız sağlığı, periodontal indeks, halk sağlığı

This article is a part of the specialty thesis titled The Relationship Between Health Literacy Level and Gum Health written by Gurbet Alev Öztaş Şahinler under the supervison by Recep Orbak.

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INTRODUCTION

Periodontium is a complex structure consisting of hard and soft tissues around the tooth. Periodontal health is perceived as the health of all tissues associated with periodontium.

Gingivitis and periodontitis are 2 common diseases affecting the periodontium.[1] There are 3 important factors: a susceptible host, the presence of pathogenic species, and beneficial microorganism deficiency in terms of the occurrence, progression, and severity of periodontal disease. While plaque formation accounts for only 20% of the risk of periodontal tissue inflammation, smoking and the presence of systemic diseases such as diabetes or genetic variations affecting the healing stages of tissue account for the remaining 80%.[2]

The most important thing to do for microbial dental plaque removal and healthy teeth and gums is to practice daily oral hygiene habits. In the examinations, it has been reported that the use of dental floss applied in addition to tooth brushing after plaque removal is effective in controlling bleeding.[3] In another study evaluating the effectiveness of the interproximal brushes, it was stated that the use of the interproximal brush was more effective on the plaque index (PI) than the use of dental floss.[4]

Health Literacy

In order to lead a healthy and a good quality of life, it is essential for individuals to reach, understand, and act in accordance with appropriate health information when necessary. As a result of the efforts to increase this awareness, the concept of "Health Literacy (SOY)" has emerged.[5]

Although health literacy was introduced to the literature with the article "Health Education as Social Policy" written by Scott Simonds in the 1970s, its importance has been better understood in recent years.[6] It has been stated that health-related information should be arranged in a way that is easy to access and simplified so that the society can understand and develop behavior.[7]

Nutbeam and Wise[8] in 1993 and Zarcadoolas et al[9] in 2005 defined health literacy as a whole, including the ability to seek, find, understand, evaluate, and make the right decision-making information and services to help individuals reduce their health risks and lead a better quality of life.

There are many personal and socio-environmental factors that affect the level of health literacy. In this context, the skills of the individual such as seeing, hearing, testing, speaking, and keeping in memory are very important. In addition, race, age, gender, educational status, general literacy level, occupation, and socioeconomic conditions are among the influencing socio-environmental factors.[10]

Many scales have been developed to evaluate the health literacy level[11] including the European Health Literacy Survey Questionnaire (HLS-EU-Q) and the Turkey Health Literacy Scale-32 (TSOY-32). The (HLS-EU-Q) is a 47-item scale developed for determining health literacy levels in European countries in the 2009-2012 period. The questionnaire consists of 3 dimensions in health processes (prevention from illness, health service delivery, and health improvement) and 4 processes in information processing (obtaining information, understanding information, evaluating information, and applying information).[12] Turkey Health Literacy Scale-32. As a result of the Turkish Adaptation of the European Health Literacy Scale (ASOY-TR) studies, it was seen that the scale measured health literacy in general, but did not provide sufficient results in some concepts. For this reason, TSOY-32 was created by updating the scale and reducing the number of questions to 32.[5]

The Importance of Health Literacy for Today's Conditions

The coronavirus disease 2019 disease, which has been going on in the world since the beginning of 2020, has been effective in understanding the importance of health literacy. Understanding the source of the disease, ways of transmission and prevention, and treatment options have played an important role in controlling the disease. For this, the importance of individual awareness of the disease, sense of responsibility, and solidarity has increased.[13,14]

Health Literacy in Dentistry

Maintaining and treating oral and dental health, which is an integral part of general health and well-being, is the primary goal of dentistry.[15] For healthy teeth and gums, the awareness of the individual should be increased in terms of lifestyle, diet habits, daily oral hygiene practices, and periodic dental visit.[16]

In this study, it was aimed to assess the relationship between health literacy level and the dental and gingival health of individuals.

MATERIAL AND METHODS

This study was carried out with a total of 342 applicants in 3 institutions with the highest number of patient admissions in Erzurum; Atatürk University Faculty of Dentistry Department of Periodontology, the Erzurum of Health Oral Dental Health Center, and the Dental Polyclinics of Mareşal Çakmak State Hospital, in the period of April-October 2019.

Ethical Approval

Ethical approval regarding the methodology and material used in this study was obtained from the Atatürk University Faculty of Medicine Clinical Research Ethics Committee (Date: 13.03.2019, Number: B.30.2.ATA.0.0/125). In addition, a written permission was obtained from the Erzurum Provincial Health Directorate since part of the study was carried out in the Erzurum of Health Oral Dental Health Center and Dental Polyclinics of the Maraşel Çakmak State Hospital. On the other hand, a private permission for using the TSOY-32 scale was obtained from Prof. Dr. Pınar Okyay via electronic mail. The individuals participating in the study were asked to read and sign the "Informed Volunteer Form."

Inclusion Criteria for the Study

The individuals included in this study were randomly selected among the patients who applied to health institutions and met the following conditions: to be over 15 years old, to be literate, to have no obstacle to fill the form for health reasons, to speak Turkish, not to be trained in the field of health and not to be from the health-care professional group, and to voluntarily accept to participate the survey.

An information form for each participant has been filled out to describe the socio-demographic information and systemic status. In the form, questions regarding age, gender, marital status, general health level, smoking habit, education level, and tooth brushing were asked.

Filling the Turkey Health Literacy Scale-32 Questionnaire

The TSOY-32 scale, of which its reliability and validation have been approved, was used. The survey was evaluated through

one-to-one communication. According to the results of the survey, individuals' health literacy levels were evaluated by scoring "very easy—4," "easy—3," "hard—2," "very hard—1," and "no idea—0." The following formula was used to calculate the index score.

$$index = (mean - 1) \times 50 \div 3$$

The Health Literacy level of each individual was evaluated in the lowest (0) and highest (50) score range according to the TSOY-32 scale. Health Literacy levels were grouped as 0-25 points "inadequate health literacy," 25-33 points "problematic-limited health literacy," 33-42 points "adequate health literacy," and 42-50 points "excellent health literacy."[5]

Evaluating Mouth, Teeth, and Periodontal Tissues Health

Following the completion of the forms, the clinical periodontal examination of the participants was performed. The Decay, Missing, Filling Total (DMFT) index was used in evaluating the number of decay, missing, and filled teeth, and the gingival index (GI) (Löe & Silness, 1963, 1967),[17] plaque index (Silness & Löe, 1964),[18] and CPITN index[19] were used to evaluate oral hygiene and periodontal tissue health. All measurements were recorded on the forms and calculated for each individual.

Statistical Analysis

The data were analyzed using the IBM Statistical Program for Social Sciences Statistics (SPSS) version 22.0 software (IBM Corp.; Armonk, NY, USA). One-way analysis of variance (ANOVA) test was used for evaluating more than 2 categorical data with numerical data, the independent sample *t*-test for 2 categorical data with numerical data, bivariate correlation test for the correlation between numerical values, and chi-square test for categorical data between groups. In all evaluations, 95% confidence interval at a 5% significance level was considered.[20]

RESULTS

A total of 342 patients, 114 applicants from each of the 3 institutions with the highest patient potential in Erzurum; Atatürk University Faculty of Dentistry Department of Periodontology, the Erzurum of Health Oral Dental Health Center, and the Dental Polyclinics of Mareşal Çakmak State Hospital, were included in this study.

The average age of the participants evaluated within the scope of the study was 36.8 ± 11.3; 60% (n = 205) were women and 40% (n = 137) were men. About 70% (n = 237) of the participants were married. Considering the education levels, 97 participants (28.4%) had primary school degree or no degree, 26 participants (7.6%) had secondary school degree, 108 participants (31.6%) had high school or equivalent degree, and 111 participants (32.5%) had university diploma or graduate degree.

About 40% (n = 138) of the research group were homemakers or unemployed, 17.3% (n = 59) were civil servants, and 13.5% (n = 46) were students. Approximately half of the participants (53.8%, n = 184) declared that their monthly incomes were less than their monthly life expenses.

It was observed that 196 individuals had at least 1 chronic disease; especially, blood pressure, diabetes, and cardiovascular disease were the most commonly reported diseases.

It was also determined that 162 participants were daily systemic drug users, and 163 were smokers.

Table 1. Mean and SD Values of Decay, Missing, Filling Total Value, and Periodontal Parameters of All Participants Participating in the Study

Parameter	Mean ± SD
DMFT value	9.43 ± 5.67
Gingival index	1.65 ± 0.60
Plaque index	1.64 ± 0.66
CPITN value	2.75 ± 0.74

CPITN, Community Periodontal Index of Treatment Needs; DMFT, decay, missing, filling total.

Findings of Clinical Examination Data

Only 119 (34.8%) participants stated that they brush their teeth once a day, and this rate was higher among the participants with a university diploma or graduate degree. However, 103 (30.1%) participants stated that they brush their teeth only when they remember, and this rate was higher among the participants with a primary education degree or had no degree.

No statistically significant differences ($P < .05$) in the DMFT value and periodontal parameters among the institutions were obtained. The mean index values of the participants are given in Table 1.

Negative correlations were obtained between the frequency of tooth brushing and the gingival, plaque, and the CPITN index. In other words, it was determined that an increased number of tooth brushings (once or twice a day, brushing once every 2 days, and brushing when remembered) decreased the gingival plaque and the CPITN index at $P < .05$.

When the relationship between educational status and periodontal parameters was examined, it was found that the evaluated parameters were significantly higher among the participants with a primary school degree or had no degree than those of the participants with a university diploma or graduate degree ($P < .05$).

Turkey Health Literacy Scale-32 Descriptive Findings

The average TSOY-32 score of the participants was determined as 22.85 ± 8, ranging from 2.60 to 41.67. The average TSOY-32 scores of the participants by considering the institutions are given in Table 2.

The health literacy level of the individuals who presented to the Faculty of Dentistry was higher than those of the participants who presented to the other 2 institutions, even though their health literacy level was "problematic and limited health literacy level" category, at $P < .05$. There were no participants whose health literacy level was in the "excellent health literacy" category in all 3 institutions.

No statistically significant differences in the TSOY-32 scores of participants among the age groups were obtained at $P < .05$ significance level. The average TSOY-32 score was found to be 22.69 ± 7.95 for female and 23.08 ± 8.08 for male participants without having a statistically significant difference between the means at $P < .05$. However, there were statistically significant differences ($P < .05$) between the education levels of the participants regarding the average TSOY-32 scores (Table 3).

Table 2. Mean and SD Values of Turkey Health Literacy Scale-32 Scores of the Institutions Included in the Study

Institution	Mean ± SD of TSOY-32 Score
Faculty of Dentistry	25.12 ± 7.8**
Health Oral Dental Health Center	21.11 ± 8.1**
Maraşel Çakmak State Hospital	22.31 ± 7.7**

TSOY-32, Turkey Health Literacy Scale-32.
**$P < .05$.

Table 3. Mean and SD Values of Turkey Health Literacy Scale-32 Scores Regarding to Education Levels

Education Level of the Participants	Mean ± SD of TSOY-32 Score
Primary school degree or no degree	18.04 ± 8.08**
Middle school degree	16.67 ± 7.61**
High school degree	23.51 ± 6.74**
University diploma or graduate degree	27.86 ± 5.32**

TSOY-32, Turkey Health Literacy Scale-32.
**P <.05.

When the relationship between the health literacy level of the participants and oral hygiene habits was examined, it was determined that an increase in health literacy index score increased the regular tooth brushing habits of individuals. The average health literacy score was found to be 25.36 for the individuals with 1 and 2 tooth brushing frequencies per day and 17.66 for the individuals who brushed their teeth when they remember (P < .05).

Negative correlations were found between the TSOY-32 score index and the DMFT value, CPITN value, gingival, and PI values (P < .01) (Table 4).

Descriptive statistics for health literacy are given in Table 5. When the responses of the participants to the health literacy items were examined, under the "treatment and service" category, the highest (55%) response for "very easy" was given to item 14 "finding the location of the unit you are looking for (laboratory, polyclinic, etc.)," and the highest responses for "very hard" (37.1%) and "don't know" (20.2%) answers were given to item 15 "deciding what to do in an emergency (accident, sudden health problem, etc.)." Similarly, the highest (75.4%) response for "easy" answer was given to the item 31 "making suggestions to your family and/or friends

Table 4. The Relationship Between the Participants' Turkey Health Literacy Scale-32 Score Indexes and Periodontal Parameters

Correlations			
		Gingival Index Value	TSOY-32 Index
Gingival index value	Pearson Correlation	1	−.282**
	Sig. (2-tailed)		.000
	N	342	342
TSOY-32 index	Pearson correlation	−,282**	1
	Sig. (2-tailed)	.000	
	N	342	342

Correlations			
		Plaque Index Value	TSOY-32 Index
Plaque index value	Pearson correlation	1	−.257**
	Sig. (2-tailed)		.000
	N	342	342
TSOY-32 index	Pearson correlation	−.257**	1
	Sig. (2-tailed)	.000	
	N	342	342

Correlations			
		CPITN value	TSOY-32 Index
CPITN value	Pearson correlation	1	−.236**
	Sig. (2-tailed)		.000
	N	335	335
TSOY-32 index	Pearson correlation	−.236**	1
	Sig. (2-tailed)	.000	
	N	335	342

Correlations			
		DMFT Value	TSOY-32 Index
DMFT value	Pearson Correlation	1	−.324**
	Sig. (2-tailed)		.000
	N	342	342
TSOY-32 index	Pearson correlation	−.324**	1
	Sig. (2-tailed)	.000	
	N	342	342

CPITN, Community Periodontal Index of Treatment Needs; DMFT, decay, missing, filling total; sig., significance; TSOY-32, Turkey Health Literacy Scale-32.
**P < .01.

Table 5. Descriptive Statistics of Health Literacy

Health literacy	Mean ± SD	Median	Mimimum–Maximum
Understanding health-related information	24.15 ± 9.01	18.79	0.00-45.83
Accessing health-related information	18.71 ± 10.22	27.08	0.00-41.67
Using/applying health-related information	30.68 ± 7.26	18.75	0.00-37.50
Evaluate health-related information	17.86 ± 8.93	31.25	12.50-43.75

to be healthier," and the highest (25.9%) response for "very difficult" answer for the item 29 "your lifestyle for your health (doing sports, healthy eating, not smoking, etc.)," and the highest (30.4%) response for "don't know "for the item 32 "interpreting health-related policy changes," under the 'protection from diseases and improving health' category.

DISCUSSION

Oral and dental health is an inseparable component of general health. For increasing the health level of society, special attention should be given to increase oral and dental health level as well as general health knowledge, and individual health awareness should be created. Within the health literacy concept, although many studies have been carried out and evaluating scales have been developed in the fields of medicine and nursing, the number of studies in the field of Dentistry is very limited.

This study, aiming to evaluate the relationship between health literacy level and teeth and gums health parameters, is a pilot study in the field of dentistry at the level of specialization thesis.

The study was carried out in 3 health-care institutions with high and different patient potentials, one of which was the Faculty of Dentistry Atatürk University, in Erzurum city center. For the sample size, the minimum number of individuals was determined as 320 by taking into account the suggestions[21] of at least 10 individuals per "item" directed in the survey, but 342 individuals were included in the study.

The DMFT index, PI, and GI developed by Löe & Silness[17,18] were used to evaluate the health of teeth and gums by stating oral hygiene habits. These indexes were preferred for the reasons of ease of application and widespread use. CPITN value gives an idea about periodontal pocket depth and related treatment planning. However, it does not provide information about attachment loss, which is critical in the evaluation of periodontal disease.[19] However, evaluation of attachment loss was not included in the study, since the individuals who applied to the clinics for the purpose of treatment may have experienced discomfort due to the length of the study.

While examining people's understanding of the health system, their participation, their ability and motivation to take responsibility for their own health in the societies, and the literacy levels of individuals and the society should be evaluated first.

In this study, TSOY-32,[5] which has been updated and has a reduced number of questions, was developed based upon the European Health Literacy Project (HLS-E).

The average TSOY-32 score of our study groups was found to be 22.8 over 50 and evaluated as "inadequate." Although there was no published research article on TSOY-32 scores using periodontal parameters in Turkey, several studies in medicine were reported on general health literacy. In a study carried out at University of

Adnan Menderes University Faculty of Medicine Department of Public Health, the health literacy score by the TSOY-32 was found to be 29.5.[5] In another study conducted with 1003 students at the University of Sivas Cumhuriyet University, it was determined that 62.8% of participants had "sufficient and excellent health literacy level" according to the TSOY-32 score.[22]

The health literacy level of the participants selected from the Faculty of Dentistry was higher than those of the participants from the other 2 institutions, even though it was evaluated as "problematic-limited health literacy level." This difference might be due to the fact that the faculty is preferred more by university employees and university students and also because of transferred patients from other institutions for advanced treatments by more experienced academicians.

There was no significant difference in the health literacy general index scores between the age groups, even though the health literacy levels of individuals over 45 years old was lower, similar to the results stated by Özdemir et al.[23] It has been pointed out that this relationship could be linked to reasons such as difficulty of individuals to follow technological changes, their distance from social life, and need of help from family members as they get older.[24]

General literacy is considered to be an individual's literacy, understanding, and interpretation of what person reads and is an important point for health literacy. Many studies indicated that individuals with low literacy levels had difficulties in understanding and interpreting health-related information. Tanrıöver et al[15] and Okyay et al[5] reported that there were positive correlations between the educational levels of individuals and their health literacy levels. In our study, it was obtained that TSOY-32 scores increased significantly with increasing educational level of individuals.

When the relationship between the frequency of teeth brushing and the level of health literacy of individuals was evaluated, it was seen that individuals with high health literacy brush their teeth at more regular intervals. The findings of our study agreed with that of the literature. Acar[25] found that the number of teeth brushing was higher for individuals with at least high school education than those of individuals with a lower educational level than high school.

Although there were no statistically significant differences found in the DMFT value and periodontal parameters of the participants among the institutions, it was observed that the individuals with high health literacy levels in all 3 institutions had lower DMFT values, GI, PI, and CPITN values. It was also figured out that the individuals with higher health literacy levels were more conscious about oral hygiene habits.

Some studies have shown that children, their parents, and adults with high health literacy levels have better oral hygiene habits and a lower DMFT index. The low number of tooth decays and losses and the high number of surviving teeth ensure that people have adequate oral health in terms of physical, functional, phonetic, and aesthetic characteristics.[26-28]

Mamaklıoğlu et al[29] examined the relationship between the TSOY-32 scores and the periodontal parameters of pregnant women and reported that the TSOY-32 level in pregnant women was significantly higher than that of non-pregnant women. However, they have not reported any significant relationship between TSOY-32 level and periodontal parameters. In their another study[30] with the dentistry students of Marmara University, it was obtained that the increase in the level of education positively affected the SOY level and contributed to the reduction of the findings associated with periodontal inflammation.

In a study investigating the effect of health literacy on benefiting from preventive dentistry practices among Somali refugees in Massachusetts, the Short Test of Functional Health Literacy in Adults scale was used, and it was found that the participants with higher health literacy benefited from preventive practices 2 times more than the others, and the individuals with wider vocabulary were 1.8 times more likely to have preventive practices.[31]

The general and health literacy levels of individuals are undoubtedly of great importance in oral, dental, and gingival health. However, the main issue is to increase the level of oral health literacy.

In a study examining the effect of oral health literacy level on daily oral hygiene habits using the Rapid Estimation of Adult Literacy in Dentistry (REALD-30) scale in Australia, it was found that the individuals with low REALD scores rarely brushed their teeth, did not have a toothbrush, and had insufficient knowledge about oral hygiene habits ($P < .05$). It was also determined that the dental treatment needs of women and the elderly were higher.[32]

Similarly, it was determined that there was a negative correlation between oral health literacy and clinical parameters, and individuals with high oral health awareness had more adequate oral hygiene habits.[33] As a result of these studies, oral health literacy as well as general and health literacy has been shown to be significantly effective on oral hygiene practices and parameters that show oral health.

The responses given to the "items" of the health literacy scale in our study were similar to the results reported by Okyay et al.[5]

In addition to these topics, the relationship between oral health and systemic health has been studied extensively, and the relationship between them has been confirmed. The mouth is the most bacteriologically dense area of the human body after the anus. It is quite normal for the other organs of individuals with poor oral health and advanced periodontal problems to be affected by this condition. Oral health significantly affects the upper respiratory tract, heart health, insulin metabolism, gastrointestinal tract, pregnant women, and infant health. In our study, individuals with high health literacy were determined to have better oral health. Indirectly, it can be predicted that this situation will positively affect systemic health.

It was determined in this study that (1) oral and dental health is directly related to the general and health literacy level; therefore, in order to be systemically healthy, dental and gingival health should be given due importance; (2) individuals with high health literacy level pay more attention to their oral hygiene habits, and their teeth and gums health are better. Their tooth brushing habits and dentist controls are more regular; therefore, the DMFT values, plaque and GI values, and CPITN values are lower; and (3) among the individuals with high health literacy level, there are individuals who have dental and gum problems and insufficient knowledge about what to do, how to do, and which health institution to go. It was concluded that it is extremely necessary to increase oral and dental health literacy besides the general and health literacy.

Study Limitations

In the study, the relationship between the general health literacy level of the patients and their oral health was examined. Oral and

dental health literacy level had not been evaluated (as there is no validated and reliable scale on this subject).

In addition, the addition of clinical attachment level and probing bleeding indices, which are used in the evaluation of periodontal health, could have made the study more powerful.

Ethics Committee Approval: Ethical approval regarding the methodology and material used in this study was obtained from the Atatürk University Faculty of Medicine Clinical Research Ethics Committee (Date: 13.03.2019, Number: B.30.2.ATA.0.0/125). In addition, a written permission was obtained from the Erzurum Provincial Health Directorate since part of the study was carried out in the Erzurum of Health Oral Dental Health Center and Dental Polyclinics of the Maraşel Çakmak State Hospital. On the other hand, private permission for using the TSOY-32 scale was obtained from Prof. Dr. Pınar Okyay via electronic mail.

Informed Consent: The individuals participating in the study were asked to read and sign the "Informed Volunteer Form."

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Author Contributions: Concept – R.O., G.A.Ö.Ş.; Design – R.O.; Supervision – R.O.; Resources – R.O., G.A.Ö.Ş.; Materials – R.O.; Data Collection and/or Processing – G.A.Ö.Ş.; Analysis and/or Interpretation – R.O., G.A.Ö.Ş.; Literature Search – G.A.Ö.Ş.; Writing Manuscript – G.A.Ö.Ş.; Critical Review – R.O.

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Hasta Onamı: Bu çalışmaya katılan kişilerden "Bilgilendirilmiş Gönüllü Onam Formu"nu okuyup imzalamaları istenmiştir.

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Effect of Denture Cleansers on Color Stability of Acrylic and Composite Artificial Teeth

Protez Temizleme Solüsyonlarının Akrilik ve Kompozit Yapay Dişlerin Renk Kararlılığına Etkisi

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ABSTRACT

Objective: The aim of this study was to evaluate the effects of different immersion solutions and denture cleansers on the color stability of acrylic and composite artificial teeth.

Methods: Maxillary anterior and premolar teeth in A2 color were used from 2 different types of artificial tooth materials (n = 8) in the study. After artificial teeth were kept in distilled water, coffee, and tea solutions at 37°C for 7 days, test specimens were immersed in distilled water, alkaline peroxide, and sodium hypochlorite denture cleansers. Color changes were measured by spectrophotometer using the CIE L*a*b* system when specimens were obtained, after exposure to immersion solutions, and after washing with denture cleaners, then color differences (ΔE) were calculated. The obtained data were analyzed with the Student's *t*-test, 2-way analysis of variance (ANOVA), 3-way ANOVA, and Bonferroni multiple comparison tests ($P = .05$).

Results: After being kept in immersion solutions, the highest Δ*E* values were observed in the composite artificial tooth specimens, and the highest color difference value was observed in the coffee solution group. There was no statistically significant difference between the denture cleansers in terms of the effect of the materials on the color change ($P > .05$).

Conclusion: While the most color difference was observed in the composite material among the artificial denture materials applied with cleaning solutions, there was no difference between the denture cleansers in terms of cleaning efficiency.

Keywords: Acrylic, artificial teeth, coloring, composite, denture cleansers

ÖZ

Amaç: Bu çalışmanın amacı; farklı daldırma ve protez temizleme solüsyonlarının akrilik ve kompozit yapay dişlerin renk kararlılığı üzerindeki etkilerini değerlendirmektir.

Yöntemler: Çalışmada iki farklı yapay diş materyaline ait A2 renginde maksiller anterior ve premolar dişler kullanıldı (n=8). Yapay dişler; distile su, kahve ve çay solüsyonlarında 37°C'de 7 gün süre ile bekletildikten sonra, distile su, alkalen peroksit ve sodyum hipoklorit protez temizleme solüsyonlarına daldırıldı. Renk değişimleri, örnekler elde edildiğinde, daldırma solüsyonlarına maruz bırakıldıktan sonra ve protez temizleyicileri ile yıkandıktan sonra CIE L*a*b* sistemi kullanılarak spektrofotometre aracılığıyla ölçüldü ve renk farklılıkları (ΔE) hesaplandı. Elde edilen veriler student t-testi, iki yönlü ANOVA, üç yönlü ANOVA ve Bonferroni çoklu karşılaştırma testleri ile analiz edildi (P =0,05).

Bulgular: Daldırma solüsyonlarında bekletildiken sonra en yüksek ΔE değerleri kompozit yapay diş örneklerinde, en yüksek renk farkı değeri ise kahve solüsyonu grubunda gözlendi. Protez temizleme solüsyonları arasında, materyallerin renk değişimine etkisi açısından istatistiksel olarak anlamlı bir fark bulunmadı (P >0,05).

Sonuç: Temizleme solüsyonları uygulanan yapay diş materyalleri arasında en fazla renk değişimi kompozit materyalinde görülürken, temizleme solüsyonları arasında, temizleme etkinliği açısından bir fark bulunmamıştır.

Anahtar Kelimeler: Akrilik, kompozit, renklendirme, protez temizleyicileri, yapay diş

INTRODUCTION

Artificial teeth are prone to discoloration. Color changes, caused by the frequent exposure to coloring liquids in the oral environment, can impact the overall aesthetics and long-term quality of these prostheses as well as patient satisfaction.[1,2] For this reason, artificial teeth must have high color stability to maintain their aesthetic appearance.[1] The color stability of prosthesis has been extensively investigated after immersion in different beverages and solutions,[3-5] such as coffee, red wine, tea, and disinfectant solutions.[6-8]

Porcelain, acrylic resin, reinforced acrylic resin, and composite resin are some of the materials used in the production of artificial teeth.[9] Among these, reinforced acrylic and composite resin teeth are used in place of acrylic resin teeth, which have low wear resistance; however, there are some concerns regarding their color stability when exposed to coloring solutions.[5,9] To the authors' knowledge, there is only 1 published study[10] on the color stability of composite artificial dental material.

The hypotheses of this study are:

1. There is no difference between acrylic and composite artificial dental materials in terms of color change after dipping solutions, holding and cleaning solutions, and cleaning processes.
2. There is no difference between the immersion solutions in terms of the color changes they cause in acrylic and composite artificial tooth materials.
3. There is no difference between the cleaning solutions in terms of the color changes they create in acrylic and composite artificial tooth materials.

MATERIAL AND METHODS

According to a study by Mutlu-Sagasen,[11] power analysis was performed to determine the minimum number of samples required for this study; 8 samples were used for each subgroup. In this study, maxillary right and left, central, lateral, canine, and premolar teeth were used.

Preparation of Samples

Three-layered acrylic (Eray, Eraylar, Ankara, Turkey) and composite (Eray Plus, Eraylar, Ankara, Turkey) artificial teeth of the same brand, color (A2), shape, and size (G2-M2; U2-P2) were used. Each tooth of the same material was embedded in autopolymerizing polymethylmethacrylate resin (PMMA; Meliodent, Kulzer GmbH) paste prepared according to the manufacturer's instructions, with the buccal surface parallel to the ground and the corresponding tooth to the midline. The samples were kept in distilled water at 37 ± 2°C for 24 hours in a dark environment. At the end of this period, the samples were dried on blotting paper (Kimwipes Lite 200, Kimberly Clark Corp., Roswell, Ga, USA) for the first color measurements of the samples. Acrylic and composite dental materials were divided into 9 subgroups, with 1 pair of maxillary central, lateral, canine, and premolar teeth in each subgroup (n = 8). The experimental groups in the study are given in Table 1.

Table 1. Experimental Groups

Immersion Solutions	Cleaning Solutions	Acrylic Tooth	Composite Tooth
Distilled water	Distilled water	ADD	CDD
	Sodium hypochlorite	ADS	CDS
	Alkaline peroxide	ADA	CDA
Tea	Distilled water	ATD	CTD
	Sodium hypochlorite	ATS	CTS
	Alkaline peroxide	ATA	CTA
Coffee	Distilled water	ACD	CCD
	Sodium hypochlorite	ACS	CCS
	Alkaline peroxide	ACA	CCA

Preparation of the Immersion Solutions

In each group, 300 mL of distilled water was used in the control group. Tea (bag tea, Lipton Yellow Label Tea, Unilever Turkey, Istanbul, Turkey) and coffee (Nescafe Classic, Nestle, Bursa, Turkey) solutions were prepared according to the manufacturer's instructions. For the tea solution, 2 × 2 grams of prefabricated tea bag were added to 300 mL of boiling water and allowed to steep for 10 minutes; the coffee solution was prepared by mixing 3.6 g of coffee powder with 300 mL of boiling water and infusing for 10 minutes. Both solutions were filtered using filter paper. All samples were immersed in the solutions and kept in the incubator at 37 ± 2°C in a dark environment for 7 days. The solutions were mixed every 24 hours to avoid any precipitation in the tea and coffee solutions.

Application of Cleaning Solutions

After 7 days, the samples were removed from the immersion solutions, washed under running water, and air-dried with water spray. Second, color measurements of the samples were made from the buccal midpoints of the teeth using the first mode in the spectrophotometer (VITA Easyshade® V; VITA Zahnfabrik, Bad Säckingen, Germany), which is recommended in "determination of basic color in the selection of prosthetic teeth." Cleaning solutions were prepared such that there was an equal amount of liquid in all groups. Samples in the control group were washed with distilled water; those in the sodium hypochlorite group were washed with 0.5% sodium hypochlorite (NaOCl, Lider Chemical Industry, İstanbul, Turkey) solution; whereas samples in the alkaline peroxide group were washed in a cleaning solution prepared by dissolving 1 denture cleaner tablet (Corega Tabs, Block Drug Company, Inc., NJ, USA) in 200 mL of warm distilled water as per the manufacturer's instructions. According to the instructions, these samples were to remain in the alkaline peroxide group for 5 minutes. For this reason, all samples in the other groups were kept in the cleaning solution for 5 minutes to ensure standardization among the cleaning solutions. The samples were washed under running water and dried with blotting paper. The third color measurements of these samples were made. Data were analyzed statistically.

Identifying Color Differences

Spectrophotometers can reliably measure the color of artificial teeth and express the measured tooth color based on 3 coordinate values (L*, a*, and b*) that locate the measured tooth color in the CIELAB color space. L* coordinate represents tooth brightness, the a* value represents red or green color, and the b* value represents yellow or blue color. The color difference (ΔE) of the 2 teeth is then determined by comparing the differences between the respective coordinate values for each tooth using the formula: $\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$. The numerical description of the color allows for precise identification of the magnitude of the color difference between measurements. In this study, the ΔE formulation was used to compare the L*, a*, and b* differences between the first, second, and third color measurements of the same tooth in color parameters. Three repetitive measurements were made from the labial midpoints of the teeth with a spectrophotometer, and the average of the L*, a*, and b* measurements was taken.

Statistical Analysis

Data analysis was performed using the Statistical Package for Social Science Statistics software, version 24.0 software (IBM Corp.; Armonk, NY, USA). Results were presented as mean difference values. The Student's *t*-test was used to compare differences between acrylic and composite artificial dental materials, and 2-way analysis of variance (ANOVA) and 3-way ANOVA tests were used to determine color differences after immersion and cleaning procedures. The Bonferroni test was used for post hoc analysis. The level of significance for all statistical analyses applied was $P = .05$.

RESULTS

The color differences in acrylic and composite artificial tooth materials after dipping and cleaning solutions are shown in Figure 1. While there was no statistically significant difference between the first and second measurements of acrylic and composite materials ($P > .05$). The color changes in acrylic and composite materials after soaking in dipping solutions were similar. There was a statistically significant difference between the second and third measurements in acrylic and composite materials ($P < .05$). The color change measured in the composite material was greater than the color change measured in the acrylic material. Also, a statistically significant difference occurred between the first and third measurements of acrylic and composite materials ($P < .05$). The color change measured in the composite material was greater than the color change measured in the acrylic material (Table 2).

According to a 2-way ANOVA, there was no statistically significant difference in the effect of staining solutions on the color change of acrylic and composite materials ($P > .05$).

The effect of cleaning solutions on the color change of the materials was evaluated with a 2-way ANOVA test and no statistical difference was found between the cleaning solutions for both acrylic and composite material at the end of the cleaning process ($P > .05$). While the color change in acrylic material as a result of washing with cleaning solutions was not statistically significant ($P > .05$), results were statistically significant in the composite material ($P < .05$) (Table 3).

Post hoc tests were carried out to determine the cause of the difference in the composite material with the coloring solutions. According to the results, the coffee solution group had the most effect on color change, but the least color change was observed in this group after the cleaning process (Table 4).

Color differences in acrylic and composite artificial tooth materials after dipping and cleaning solutions are presented in Figure 1.

DISCUSSION

In this study, 2 different artificial tooth materials were cleaned with different cleaning solutions after being kept in dipping solutions. Color changes were measured by means of a spectrophotometer after 7 days in immersion solutions and after cleaning with cleaning solution. Our results showed that the color change seen in the composite material was higher than that in the acrylic material. Therefore, the first hypothesis of the study was rejected. The coffee solution was significantly more effective in terms of the color changes caused by artificial dental materials. Based on this observation, the second hypothesis of the study was rejected. In the case of the cleaning solutions, there was no significant difference between cleaning solutions, and the third hypothesis of the study was accepted.

Tieh et al[12] conducted a systematic review of studies that investigated the optical properties and color stability of various artificial teeth: polymethylmethacrylate (PMMA), double cross-linked PMMA, nanocomposite, composite, porcelain, computer-aided design/computer-aided manufacturing (CAD/CAM), and 3-dimensional (3D) produced artificial dental materials. In these studies[3,4,6,13,14] the most assessed artificial tooth material was PMMA; only 1 study[10] researched composite tooth material. In most studies, maxillary anterior teeth, which provide a large

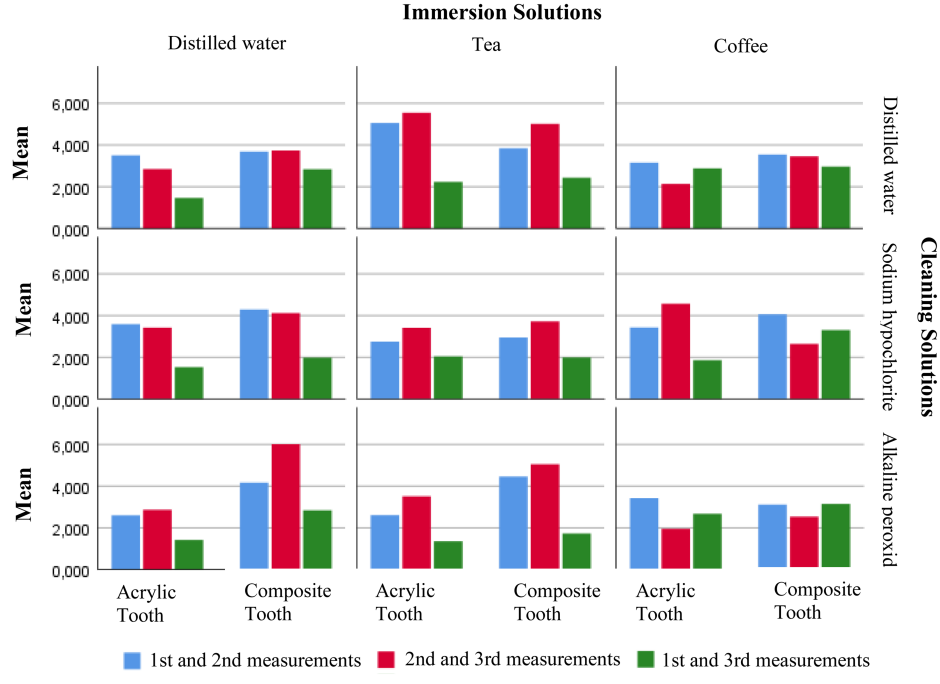

Figure 1. Color differences in acrylic and composite artificial tooth materials after dipping and cleaning solutions.

Table 2. Student *t*-test results

	t	*df*	*P*	Mean Difference
First and second measurements	−1.546	142	.124	−0.445
Second and third measurements	−1.997	142	.048*	−0.669
First and third measurements	−2.897	142	.004*	−0.641

*$P < .05$.

Table 3. Two-way Analysis of Variance Results

Material	Solution	*P*
Acrylic	Immersion solutions	.056
	Cleaning solutions	.185
Composite	Immersion solutions	.001*
	Cleaning solutions	.146

*$P < .05$.

Table 4. Post hoc test results of composite material

Immersion Solution	Cleaning Solutions	*P*
Tea	Coffee	.005*
	Distilled water	1
Coffee	Tea	.005*
	Distilled water	.004*
Distilled water	Tea	1
	Coffee	.004*

*$P < .05$.

and flat surface area, are preferred,[14-16] especially maxillary central incisors.[12] Also, a standard shade of color was determined for comparison of color change, with Vita A2 tooth color being the most commonly preferred in studies.[14-16] In vitro studies generally utilize different immersion solutions, immersion times, and aging protocols.[3,4,6,7,10,13,14] Distilled water is mostly used as the control group,[3,13] and commonly used dipping solutions based on their coloring effect are coffee, Coca-Cola, red wine, and tea.[12] Immersion times vary between studies,[4,6,7,13,14] but the most commonly used time periods are 7, 14, and 15 days.[12] Also, studies evaluating the optical properties and color stability of artificial teeth investigate denture cleaners containing alkaline peroxide[8,15] or sodium bicarbonate, solutions of sodium hypochlorite at different concentrations (0.5%, 1%, 2%, 5.25%)[8,15,17,18] and disinfectant solutions[19] such as povidone-iodine, chlorhexidine gluconate, and glutaraldehyde.[18]

Different methods can be used to determine tooth color, such as color scales that enable visual but subjective comparisons, and spectrophotometers that enable instrumental and objective measurements.[20] Tieh et al[12] stated that the use of spectrophotometers is the most common method for color measurement in studies on the optical properties and color stability of artificial teeth, and the most commonly used spectrophotometer device was Vita Easy Shade. For all these reasons, in this study, maxillary anterior and premolar acrylic and composite artificial teeth in A2 color were kept in distilled water and in coffee and tea solution for 7 days, and afterward they were cleaned with distilled water, sodium hypochlorite, and alkaline peroxide solution before color measurements were made with the Vita Easy Shade device.

Pişkin et al[18] evaluated the effects of different chemical disinfectants, i.e., neutral soap, 2% sodium hypochlorite, 5.25% sodium hypochlorite, sodium perborate, povidone-iodine, chlorhexidine gluconate, and glutaraldehyde, on the color stability of acrylic maxillary central teeth and reported that these disinfectants affect the color values of acrylic teeth. Freire et al[8] evaluated the effects of different cleaning protocols and accelerated artificial aging on the color stability of PMMA maxillary central teeth. They treated these teeth with alkaline peroxide for 5 minutes and 0.5% sodium hypochlorite solution for 20 minutes and reported that the color stability of acrylic artificial teeth was affected by cleaning solutions and artificial aging at the end of the experiment. Our results differ from the results of Pişkin et al[18] and Freire et al[8]'s studies; the reason is that different artificial dental materials, retention times, and different disinfectant solutions were used in these studies, as was the application of different concentrations of sodium hypochlorite solution for a longer time.

Kurtulmuş-Yılmaz and Deniz[15] evaluated the staining susceptibility of 3 different artificial teeth (acrylic, 1 cross-linked acrylic, and 1 nanocomposite maxillary central teeth) and the stain removal efficiency of denture cleaners containing potassium monopersulfate, sodium perborate, and 0.5% sodium hypochlorite. They reported that cross-linked acrylic and nanocomposite artificial teeth were more prone to discoloration and that all these denture cleaners were equally effective in cleaning artificial teeth. The results are similar to the results of this study. In the case of in vivo studies, Rosentritt et al[21] observed no significant relationship between consumption patterns and cleaning methods, while Barão et al[22] reported a significant relationship between the color change values of artificial teeth and coloring solutions.

This in vitro study evaluated the effects of dipping solutions and cleaning solutions on the color change of acrylic and composite artificial teeth. There was no statistically significant difference between dipping solutions and cleaning solutions. The color change was only observed in the composite material, and this was caused by coffee. Coffee solution is one of the most frequently used solutions in studies,[12] and the solution that produces the most color difference is the coffee solution,[23,24] while the tea solution creates the least color change.[15,25]
Within the limitations of this study,

- The color change in composite artificial tooth material was greater than in acrylic artificial tooth.
- Coffee solution has a coloring effect.
- There is no difference between the cleaning solutions applied in accordance with the manufacturer's instructions in terms of the color change caused by the cleaning solutions.

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Evaluation of Nasopalatine Canal Morphology by Cone-Beam Computerized Tomography

Nazopalatin Kanal Morfolojilerinin Konik Işınlı Bilgisayarlı Tomografi ile Değerlendirilmesi

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ABSTRACT

Objective: A crucial anatomical component that joins the nasal cavity and oral cavity is the nasopalatine canal, which is located in the front region of the maxilla. This study aims to examine the morphology of the nasopalatine canals in cone-beam computed tomography (CBCT) images.

Methods: Sagittal CBCT images from 100 patients (50 females and 50 males, mean age 38.03 ± 12.98) were examined retrospectively. The nasopalatine canal was studied in 6 groups. Furthermore, the inferior and superior diameters and lengths of the nasopalatine canal were measured and assessed in male and female patients. For statistical analysis, the 1-way analysis of variance test was used to compare the parameters across groups in quantitative data comparison, and to compare qualitative data, the exact chi-square test and Halton–Fisher–Freeman were utilized. The level of significance was set at $P < .05$.

Results: The most prevalent nasopalatine canal shape was cylindrical (31%), with a ratio of 15% in females and 16% in males. The least frequent nasopalatine canal shape in both genders was tree branch (5%), while it was 3% in males and 1% in females. The average length of the nasopalatine canal in female patients was 9.40 ± 2.19 mm and 11.59 ± 2.45 mm in male patients. There was no statistically significant variation between canal types based on gender ($P > .05$).

Conclusion: The nasopalatine canal's anatomical features are varied. It is critical to use 3-dimensional conical beam computed tomography before proceeding with any treatment in the premaxilla region. Knowing the morphological variations of the canal allows spotting pathological alterations easily.

Keywords: Anatomical variation, cone-beam computed tomography, nasopalatine canal

ÖZ

Amaç: Maksilla anterior bölgede yerleşim gösteren nazopalatin kanal ağız kavitesi ve nazal kaviteyi birbirine bağlayan önemli anatomik yapılardan birisidir. Bu çalışmanın amacı, Konik Işınlı Bilgisayarlı Tomografi (CBCT) görüntülerinde nazopalatin kanal morfolojilerinin değerlendirilmesidir.

Yöntemler: Toplam 100 hastanın (50 kadın 50 erkek, ortalama yaş 38,03 ± 12,98) retrospektif görüntüleri sagittal kesitte değerlendirilmiştir. Nazopalatin kanal 6 farklı grupta sınıflandırılmıştır. Kadın ve erkeklerde nazopalatin kanalın inferior ve superior çapı ve uzunluğu ölçülerek değerlendirilmiştir. İstatistiksel analiz için, nicel verilerin karşılaştırılmasında, parametrelerin gruplar arası değerlendirilmesi için tek yönlü varyans analizi testi, nitel verilerin karşılaştırılmasında ise kesin ki-kare testi ve Halton-Fisher-Freeman kullanılmıştır. Anlamlılık düzeyi $P < .05$ olarak belirlenmiştir.

Bulgular: Nazopalatin kanal morfolojisinin cinsiyete dayalı değerlendirmesinde en sık görülen nazopalatin kanal morfolojisinin tip 1 (silindir, 31%) şeklinde olduğu ve bu oran kadınlarda 15% ve erkeklerde 16% olarak saptanmıştır. Çalışmada her iki cinsiyette toplamda en az görülen nazopalatin kanal morfolojisinin tip 5 (ağaç dalı, 5%) olduğu, cinsiyete göre değerlendirildiğinde ise erkeklerde 3% ve kadınlarda ise %1 oranında bulgulanmıştır. Çalışmamızda nazopalatin kanalın ortalama uzunluğu kadın hastalarda 9,40±2,19 mm, erkek hastalarda ise 11,59±2,45 mm olarak saptanmıştır. Nazopalatin kanal morfolojisinde kadın ve erkek hasta görüntülerinin incelenmesi sonucunda sınıflar arasında istatistiksel olarak anlamlı farklılık saptanmamıştır ($P > .05$).

This study was presented as an oral presentation in 1st International Turkish-Japanese Dental Congress that was held on June 24-26th, 2021 in Ankara, Turkey.

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Sonuç: Nazopalatin kanal farklı anatomik yapılara sahiptir. Konvansiyonel dental radyografiler iki boyutlu olması sebebiyle değerlendirmede yetersiz kalmaktadır. Bu sebeple üç boyutlu değerlendirme imkanı sunan konik ışınlı bilgisayarlı tomografi kullanımı önemlidir. Kanalın morfolojik yapısı ve varyasyonlarının iyi bilinmesi patolojik değişimlerin tespit edilmesinde kolaylık sağlamaktadır.

Anahtar Kelimeler: Anatomik varyasyon, konik ışınlı bilgisayarlı tomografi, nazopalatin kanal

INTRODUCTION

The nasopalatine canal, which Stenson first discovered in 1683, is located midline, palatal to the maxillary central teeth. The nasopalatine canal (NPC) is the most noticeable anatomical development in the anterior maxilla. It is often found posterior to the maxillary incisors and in the midline of the maxilla, where it is also known as the incisive canal or anterior palatine canal.[1] This canal joins the incisive foramen with the oral cavity as well as the nasal cavity and the Stenson foramina.[2] The palatine artery and nerve, including fibrous, adipose, and small salivary glands, can be found in NPC, which is covered by cortical bone.[3,4] Trauma, tooth loss, cysts, surgical operations, and orthodontic treatments can all impact the anterior region of the maxilla, known as the premaxilla. It is critical to understand the anatomy and morphology of the region in order to improve the efficacy of treatments and interventions.[5,6]

Because the maxilla anterior region is prone to trauma and tooth loss, implant procedures are widely used in this location. There are limitations on critical anatomical features as well as the sufficiency of the bone structure in implant applications.[7] Due to the NPC, which is positioned in the premaxilla, proper surgical planning is required. The osteointegration of poorly positioned implants in contact with fibrous tissues in the nasopalatine canal may cause complications.[8] With surgeries performed on the maxilla anterior area, it has a significant impact on the patient's speech function and facial appearance. Understanding the anatomical structures and morphologies in this region, which has a significant impact on the patient's life comfort and psychology, leads to the effectiveness of the procedures used.[9]

The most important goal of preoperative planning is to identify anatomical structures and their variations with 2- and 3-dimensional imaging techniques and to prevent possible interventional complications.[8,9] Panoramic and periapical films are frequently used in the diagnosis and treatment follow-up of the premaxillary region. Nevertheless, acquiring 2-dimensional data with these imaging methods does not allow for adequate assessment.[10] Cone-beam computed tomography (CBCT), which is frequently preferred in the 3-dimensional evaluation of maxillofacial structures in recent years, comes to the fore with its low radiation dose and distortion. Three-dimensional (3D) imaging technique allows preoperative evaluation of bone and anatomical structures as well as surgical planning.[11,12] Preoperative examination with CBCT devices with reduced radiation doses, in addition to the normally used panoramic radiographs, is advised in high-risk situations.[13-15] Understanding the anatomical formations and variations, as well as identifying them using modern imaging tools prior to surgical treatments, will aid in treatment planning and the prevention of post-treatment complications.

The anatomical differences, size, and typical morphological structure of the NPC have been studied in the literature.[10,16,17,18] Studies have shown that the nasopalatine canal is classified into different types with 3D imaging.[2,3,6,7] While Mardinger et al[7] evaluated the nasopalatine canal on a sagittal section in 4 different groups, Etoz et al[3] evaluated it using 6 different forms. Liang et al,[8] on the other hand, classified them in 2 groups: conical and cylindrical. The aim of this study is to evaluate the nasopalatine canal and its morphologies in the premaxilla in 3D with cone-beam computed tomography.

MATERIAL AND METHODS

The study protocol of this retrospective study was approved by Marmara University School of Medicine Non-Interventional Clinical Research Ethics Committee (Date: 20.08.2020, Number 2020/96). This study was conducted in accordance with the international ethical standard of the Helsinki Declaration (2013). The study group included over 100 patients, 50 males and 50 females, who had CBCT (Planmeca Promax 3D Mid, Planmeca Oy, Helsinki, Finland) images in the archive of Marmara University Faculty of Dentistry Department of Oral and Maxillofacial Radiology. Using the Planmeca Promax 3D Mid (Planmeca Oy, Helsinki, Finland, 2012) device, CBCT recordings of all patients were produced. The manufacturer lists 90 kV, 10 mA, and 36 seconds as the device's operational parameters. The study comprised people aged 18 and above who did not have tooth deficiency in the maxillary anterior area and did not have a disease that affected bone metabolism. Optimal images of patients who showed cysts, lesions, implants, impacted teeth, grafts, and orthodontic materials were not included in the study. Informed consent was obtained from all participants in the study.

Image Evaluation

The images obtained were evaluated in the sagittal plane, and canal shapes were classified into 6 different groups (Figure 1).

The Bornstein et al[18] approach was used to determine the morphometric parameters, Stensen foramina (SF), incisive foramen (IF), and length of the NPC. The NPC dimensions (in mm) were determined using the reformatted sagittal CBCT images using Planmeca Romexis® (Planmeca Oy, Helsinki, Finland) dental software. The length of the NPC was specified as the distance between the mid-points of IF and SF (Figures 2 and 3). The overall intraclass correlation coefficient was 0.82.

Statistical Analysis

Statistical Package for Social Science Statistics software, version 22.0 software (IBM Corp.; Armonk, NY, USA), was used to carry out the statistical analysis. The Kolmogorov–Smirnov and Shapiro–Wilks tests were used to establish the parameters' appropriateness for the normal distribution, and it was determined that the parameters were suitable for the normal distribution. In addition to descriptive statistical methods (mean, SD, and frequency), the 1-way analysis of variance test was used to compare the parameters across groups in quantitative data comparison, and the Tukey Honestly Significant Difference (HSD) test was used to evaluate the group that caused the difference. To compare the parameters between genders, the Student's *t*-test was utilized, and to compare qualitative data, the exact chi-square test

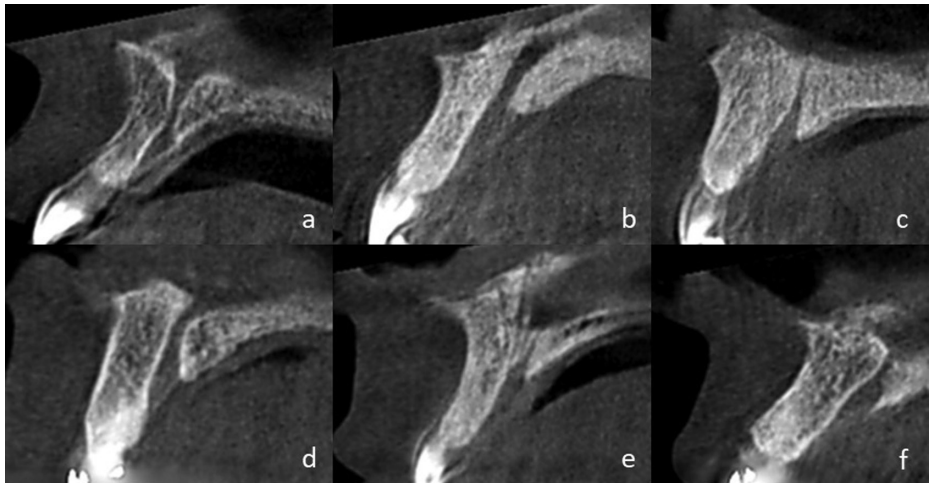

Figure 1. Nasopalatine canal classification (a) hour-glass shape, (b) cylindrical, (c) cone-shaped, (d) banana-shaped, (e) tree-branch. (f) funnel.

and Halton–Fisher–Freeman were applied. The significance was determined at the $P < .05$ level.

RESULTS

The study was conducted with a total of 100 cases, 50 females and 50 males, aged between 18 and 65 years. The mean age was 38.03 ± 12.99 years (Table 1). In our study, the nasopalatine canals were 32% cylindrical, 22% hourglass, 18% funnel, 17% banana, 6% cone, and 5% tree branch in shape (Table 2).

There was not a statistically significant difference between males and females in terms of nasopalatine canal shapes ($P > .05$) (Table 3). Moreover, there was no statistically significant difference between male and female cases in terms of mean superior and inferior diameters ($P > .05$). Yet, male mean canal length was statistically significantly greater than that of females ($P = .000$; $P < .05$) (Table 4).

There was a statistically significant difference between the superior diameter averages according to the shape of the nasopalatine canal ($P = 0.000$; $P < .05$). The superior diameter average of the cone shape was significantly lower than the cylinder, hourglass, tree branch, and banana shapes ($P < .05$). Moreover, the mean superior diameter of the banana shape was significantly lower than the hourglass shape ($P < .05$). There was no significant difference between the other shapes ($P > .05$).

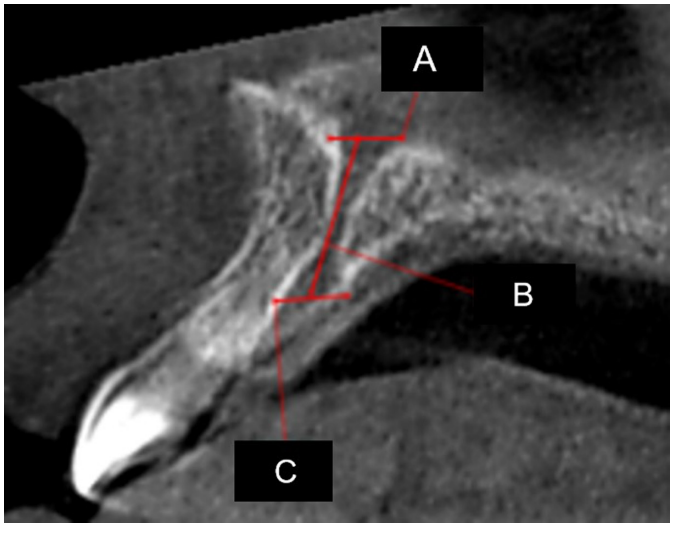

Figure 2. Anatomical structural measurements in sagittal sections on a cone-beam computed tomography image: Stensen's foramina diameter (A), nasopalatine canal length (B), and incisive foramen diameter (C).

There was a statistically significant difference between the mean diameter and the inferior diameter according to the shape of the nasopalatine canal ($P = .000$; $P < .05$). The mean diameter of the cylinder shape was significantly lower than the funnel and hourglass shapes ($P < .05$). The mean inferior diameter of the banana shape was significantly lower than the funnel shape ($P < .05$). Yet, there was no significant difference between the other shapes ($P > .05$). In addition, there was no statistically significant difference between the mean lengths according to the shape of the nasopalatine canal ($P > .05$) (Table 5); (Figure 4).

There was a statistically significant difference between the mean superior diameter in females according to the shape of the nasopalatine canal ($P = .000$; $P < .05$). The superior diameter average of the cone shape was significantly lower than the cylinder, hourglass, and banana shapes ($P < .05$). The superior diameter mean of the funnel shape was significantly lower than the hourglass shape ($P < .05$). There was no significant difference between other shapes ($P > .05$). The mean value of the inferior diameter differed statistically according to the morphology of the nasopalatine canal ($P = .002$; $P < .05$). The inferior diameter average of the funnel shape was significantly higher than the cylinder and banana shapes ($P < .05$). There was no significant difference between other shapes ($P > .05$). Moreover, there was no statistically significant difference between the mean lengths according to the shape of the nasopalatine canal ($P > .05$) (Table 6).

There is a statistically significant difference between the mean superior diameter of men according to the shape of the nasopalatine canal ($P = .000$; $P < .05$). As a result of the Tukey Honestly Significant Difference (HSD) test performed to determine which groups the significance originates from, the superior diameter average of the cone shape was significantly lower than the cylinder, hourglass, tree branch, and banana shapes ($P < .05$). The superior diameter mean of the funnel shape was significantly lower than the hourglass shape ($P < .05$). There was no significant difference between the other shapes ($P > .05$).

There is a statistically significant difference between the mean diameter and the inferior diameter according to the shape of

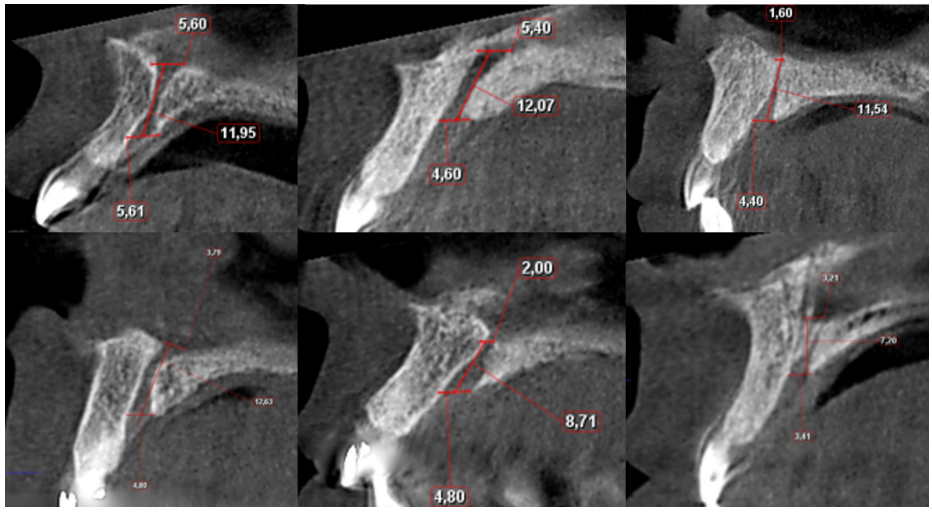

Figure 3. The images were analyzed in the sagittal plane, and the inferior and superior diameters, as well as the canal length, were measured.

the nasopalatine canal (P = .031; P < .05). The mean of the inferior diameter of the cylinder shape was significantly lower than the funnel shape (P < .05). There was no significant difference between the other shapes (P > .05). According to the nasopalatine canal's form, there is no statistically significant variation in the mean lengths (P > .05) (Table 7).

DISCUSSION

Patients have commonly favored implant applications in the restorative treatment of anterior tooth loss in recent years due to their cosmetic and functional benefits.[3,19,20] Because of biomechanical, cosmetic, and phonetic demands, implant treatments in the front maxillary area often require a precise fit despite anatomical limits. Inadequate bone thickness and the presence of NPC generate challenges in placing the implants. Osseointegration is prevented when the implants come into contact with nerve tissue. Moreover, sensory dysfunction may arise as a result of the interaction between the neural structures and the implant.[3,18] As a result, prior to surgical operations, it is critical to study the anatomical nature of this area.

Cone-beam computed tomography is one of the best methods for 3D imaging of NPC because it accurately shows the bone structures and uses less radiation.[21,22] Studies have shown that CBCT imaging and reconstruction of oral and maxillofacial tissues provide accurate and consistent linear measurements.[22,23] In their study, Guyader et al[24] compared computed tomography and CBCT images, emphasizing the benefits of CBCT. Improved CBCT resolution, the ability to do more specialized evaluations in particular locations, and generating 6 times less radiation are all significant advantages. An ideal location for comprehensive maxillary rehabilitation with dental implants is the edentulous anterior maxilla.[25] The amount of accessible bone, together with the topography and morphology of the NPC, all influence the personalized therapy approach. These specific parameters are efficiently assessed by CBCT. In the front maxilla, the buccal alveolar bone resorbs after tooth extraction, local trauma, periodontal and periradicular diseases, cysts, or malignancies.[26] The CBCT was used in earlier research to assess the NPC.[2,4,18,26,27] The authors identified many NPC anatomical variables: the diameter of the IF;[18,27,28] the length of the NPC,[3,4,9,18,21,27] and the diameter of the NPC.[10,21]

Although there have been studies on variations in canal form, there is no standardized classification system. In sagittal planes, Fernandez-Alonso et al[2] and Gönül et al[29] categorized the canal form into 4 groups (hourglass, cylindrical, funnel, and banana), although Liang et al[8] demonstrated it with only 2 groups: conical and cylindrical. In their research, Etoz and Şişman[3] and Hakbilen and Mağat[9] examined the canal form in 6 categories (hourglass, cone, banana, funnel, cylinder, and tree branch). Görürgöz et al[30]

Table 1. Age Assessment by Gender

	Age	
	Mean ± SD	*P*
Female	37.82 ± 11.75	.872
Male	38.24 ± 14.23	

Student's *t*-test.

Table 2. Shape of the Nasopalatine Canal

	n	%
Cylindrical	32	32
Funnel	18	18
Hourglass	22	22
Tree branch	5	5
Banana	17	17
Cone	6	6
Total	100	100

Table 3. Evaluation of the Shape of the Nasopalatine Canal by Gender

	Female	Male	
	n (%)	n (%)	*P*
Cylindrical	16 (32)	16 (32)	
Funnel	12 (24)	6 (12)	
Hourglass	11 (22)	11 (22)	.525
Tree branch	1 (2)	4 (8)	
Banana	7 (14)	10 (20)	
Cone	3 (6)	3 (6)	

Halton–Fisher– Freeman exact est.

Table 4. Evaluation of Diameters and Lengths by Gender

	Female	Male	
	Mean ± SD	Mean ± SD	*P*
Superior diameter	3.33 ± 1.45	3.44 ± 1.21	.674
Inferior diameter	3.72 ± 0.89	3.87 ± 0.99	.432
Length	9.41 ± 2.19	11.6 ± 2.46	.000*

Student's *t*-test; *P < .05.

Table 5. Evaluation of Superior Diameter, Inferior Diameter, and Length According to the Shape of the Nasopalatine Canal

Shape of the Nasopalatine Duct	Superior Diameter Mean ± SD	Inferior Diameter Mean ± SD	Length Mean ± SD
Cylindrical	3.60 ± 1.07^{bc}	3.36 ± 0.89^{a}	10.43 ± 2.64^{a}
Funnel	2.31 ± 1.07^{a}	4.58 ± 0.74^{b}	9.35 ± 2.05^{a}
Hourglass	4.40 ± 1.23^{b}	4.05 ± 0.98^{bc}	10.86 ± 2.46^{a}
Tree branch	3.89 ± 0.92 ^{bc}	3.53 ± 0.27^{abc}	12.73 ± 4.87^{a}
Banana	3.40 ± 0.81^{c}	3.46 ± 0.80^{ac}	11.02 ± 1.62^{a}
Cone	1.26 ± 0.38 ^{a}	3.98 ± 0.60^{abc}	9.75 ± 2.83^{a}
P	.000*	.000*	.102

One-way analysis of variance test.
Different letters (a, b, and c) in the columns indicate the difference between shape groups.*$P < .05$.

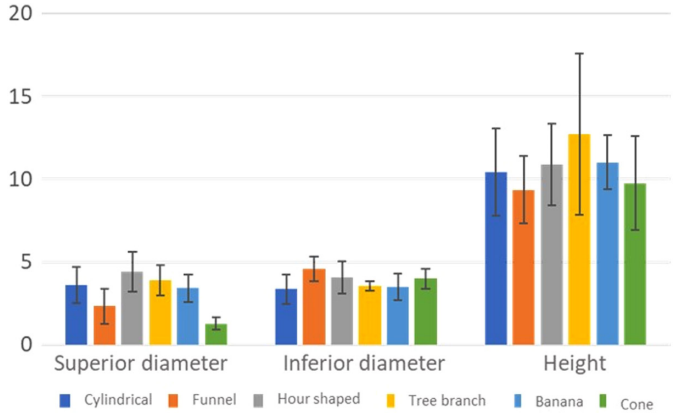

Figure 4. Evaluation of superior diameter, inferior diameter, and length according to the shape of the nasopalatine canal.

categorized NPC in sagittal sections of CBCT images as hourglass, spindle, funnel, cylindrical, cone, banana, tree branch, kink, and other. In our study, the images obtained were evaluated in the sagittal plane, and canal shapes were classified into 6 different groups (cylindrical, funnel, hourglass, tree branch, banana, and cone).

In the study of Görürgöz et al[30], the most frequent canal type was found to be hourglass-shaped in 52 (16.3%) cases and funnel-shaped in 93 (29.1%) cases. Because the NPC shape (3.1%) of 10 cases could not be classified, they were studied under the heading "other." The shapes of the male and female canals did not differ statistically significantly ($P > 0.05$). Similar to our study, there was no statistically significant difference in nasopalatine canal shapes between female and male cases ($P > .05$).

The most frequent canal form, according to Mardinger et al's[7] study, was cylindrical (46.77% of females and 34.61% of males), while banana-shaped canals were the least frequent (11.38% of females and 10.47% of males). Moreover, in Etöz et al's[3] study, the shapes of NPC in CBCT sagittal sections were grouped under 6 headings: hourglass, conical, funnel, banana, cylindrical, and tree branch. There was no statistically significant difference in the form of NPC between males and females ($P = .234$). While the highest rate of 38.78% hourglass and 27.35% funnel-shaped canals were seen in the population, it was determined that conical canals were observed at a rate of 9.18% and cylindrical canals were observed at a rate of 8.25%.[3] Mağat et al[22] stated that the most common shape type was cylindrical (29.4%), followed by conical (27.3%), funnel (15.5%), hourglass (13.9%), banana (9.4%), and tree branch (4.5%), in that order. These findings were consistent with the findings of Thakur et al,[4] Tözüm et al[21] and with our results since we have observed that the most common canal

Table 6. Evaluation of Superior Diameter, Inferior Diameter, and Length According to the Shape of the Nasopalatine Canal in Females

	Superior Diameter Mean ± SD	Inferior Diameter Mean ± SD	Length Mean ± SD
Cylinder	3.52 ± 1.12^{ab}	3.3 1± 0.63^{a}	9.39 ± 2.17^{a}
Funnel	2.43 ± 1.21^{b}	4.50 ± 0.81^{b}	8.52± 1.82^{a}
Hourglass	4.48 ± 1.44^{a}	3.87 ± 1.01 ^{ab}	9.64 ± 2.14^{a}
Banana	3.36 ± 0.78^{ab}	3.24 ± 0.75^{a}	10.75 ± 1.92^{a}
Cone	1.03 ± 0.21^{b}	3.48 ± 0.22 ^{ab}	7.94 ± 3.17^{a}
P	.000*	.002*	.184

One-way ANOVA test.
The tree branch shape was excluded from the comparison as it was seen in only 1 case.
Different letters (a, b, and c) in the columns indicate the difference between shape groups.*$P < .05$.

Table 7. Evaluation of Superior Diameter, Inferior Diameter, and Length According to the Shape of the Nasopalatine Canal in Males

	Superior Diameter Mean ± SD	Inferior Diameter Mean ± SD	Length Mean ± SD
Cylinder	3.68 ± 1.05 ^{ac}	3.42 ± 1.11^{a}	11.47 ± 2.72^{a}
Funnel	2.07 ± 0.75 ^{bc}	4.74 ± 0.62^{b}	11.00 ± 1.42^{a}
Hourglass	4.33 ± 1.04a	4.23 ± 0.96^{ab}	12.07 ± 2.22^{a}
Tree branch	3.61 ± 0.78 ^{ac}	3.56 ± 0.30^{ab}	12.72 ± 5.62^{a}
Banana	3.42 ± 0.88 ^{ac}	3.61 ± 0.83^{ab}	11.20 ± 1.45^{a}
Cone	1.48 ± 0.41^{b}	4.48 ± 0.31^{ab}	11.56 ± 0.35^{a}
P	.000*	.031*	.877

One-way ANOVA test.
Different letters (a, b, and c) in the columns indicate the difference between shape groups.*$P < .05$.

shape was cylindrical (32.0%) and the least common canal shape was tree branch (5.0%) in total.

In our study, the dimensional measurements of NPC were conducted in accordance with Bornstein et al's method.[18] The mean NPC length was 9.41 ± 2.19 mm in female cases and 11.6 ± 2.46 mm in male cases, also informing us that males' mean canal length was statistically significantly greater than females ($P = .000$; $P < .05$). The average length of NPC has been reported in the literature to be between 8.1 mm and 16.33 mm.[7,21] Bornstein et al,[18] Tözüm et al,[21] and Sekerci et al[31] found comparable mean canal lengths of 10.99 mm, 10.86 mm, and 10.8 mm, respectively; however, Mraiwa et al[10] and Liang et al[8] found shorter canal lengths. Guncu et al[32] reported that the mean canal length was 11.96 mm in males and 10.39 mm in females, which shows similarity with our study.

According to Görürgöz et al,[30] the average SF width was 2.51 ± 1.28 mm and the average IF diameter was 5.29 ± 1.37 mm. The width of IF was statistically significantly affected by the gender of the tested groups, with male participants generally having higher mean values ($P < .001$). Males had a larger SF diameter than females (mean 2.60 mm vs. mean 2.45 mm), but there were no significant differences ($P > .05$). Male patients had NPCs with a larger diameter than female patients, according to Liang et al,[8] while male patients had NPCs with a longer length, according to Bornstein et al.[18] Although there was no statistically significant difference between males and females in mean superior and inferior diameters ($P > .05$) in our study, the mean diameter of the cylindrical shape was significantly lower than the funnel and hourglass shapes ($P < .05$) in all cases. Our main limitation of the study was the small sample size, consisting of only 100 cases. Due to both the shape and dimensional differences of NPC, we think that there is a need for studies with a large study group on this subject.

Clinically noteworthy in terms of both function and esthetics are the surgical procedures performed on the anterior maxilla. The present research has shown that the NPC has a wide range of

features; as a result, dentists should take these variances into account while performing surgical treatments in the maxillary anterior area to avoid complications.

Ethics Committee Approval: Ethical approval of the study was obtained from Marmara University, Faculty of Medicine, Non-Interventional Clinical Research Ethics Committee (Date: 20.08.2020, Number 2020/96).

Informed Consent: Written informed consent was obtained from the patients who participated in this study.

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Derleme *Review*

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Fiberle Güçlendirilmiş Adeziv Köprüler Ve Uygulama Yöntemleri

Fiber-Reinforced Resin-Bonded Fixed Partial Dentures and Application Methods

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ÖZ

Diş hekimliğinde kaybedilen dişlerin restore edilmesi konusu oldukça önemlidir. Geliştirilen materyaller ve teknikler sayesinde günümüzde birçok seçenek ortaya çıkmıştır. Kron-köprü restorasyonları, hareketli bölümlü protezler, adeziv köprüler ve implant tedavileri kaybedilen dişlerin geri kazandırılmasında uygulanan tedavi seçenekleridir. Adeziv tekniklerin geliştirilmesiyle birlikte adeziv köprülerin kullanımı yaygınlaşmıştır. Fiberle güçlendirilmiş kompozitlerin sabit bölümlü protez yapımında kullanımı ise 1990'lı yıllardan itibaren artmıştır. Estetik ve mekanik özelliklerinin iyi olması, preperasyon gerekmeden de uygulanabilmesi nedeniyle günümüzde çok sık tercih edilen bir materyal haline gelmiştir. Minimal invaziv protetik bir tedavi olan bu restorasyonlar; dişlerinin aşındırılmasını istemeyen hastalarda, metal alerjisi olan bireylerde, destek dişlerin prognozunun belirsiz olduğu durumlarda, çene gelişiminin devam ettiği büyüme ve gelişme çağındaki hastalarda, diş çekimi veya implant tedavisi sonrasında dişsiz boşluğun idamesinde geçici veya daimî sabit protez olarak kullanılabilir. Fiberle güçlendirilmiş kompozit restorasyonlar ağız içinde direkt yöntemle uygulanabileceği gibi laboratuvar ortamında indirekt yöntemle de uygulanabilmektedir. Bu derlemede fiberle güçlendirilmiş adeziv köprü seçenekleri ve uygulama yöntemlerine göre yapılan çalışmalar incelenmiştir.

Anahtar Kelimeler: Rezin-bağlantılı sabit parsiyel protez, rezin-bağlantılı köprü, fiberglas ile güçlendirilmiş polimerler

ABSTRACT

In dentistry, it is very important to restore missing teeth. Nowadays, we have many options depending on the development of materials and techniques. Crown restorations, removable partial dentures, resin-bonded bridges, and implant treatments are the treatment options for the replacement of missing teeth. The use of adhesive bridges has increased with the development of adhesive techniques. The use of fiber-reinforced composites in fixed partial dentures has increased since the 1990s. Nowadays, it has become a highly preferred material due to its good aesthetic and mechanical properties and its ability to be applied without preparation. Fiber-reinforced composite restorations can be used as temporary or permanent fixed prostheses after tooth extraction or implant placement, in cases of unclear prognosis of abutment teeth, in patients with growing jaw development, or with metal allergies. Fiber-reinforced composite restorations can be applied either directly in the mouth or indirectly in the laboratory. In this review, it is aimed to explain fiber-reinforced adhesive bridge options and application methods.

Keywords: Resin-bonded fixed partial denture, resin-bonded bridge, fiberglass reinforced polymers

GİRİŞ

Estetik ve fonksiyonun elde edilmesinde dişin yapısal bütünlüğünün korunması, dikkat edilmesi gereken önemli kurallardan biridir. Eksik dişlerin kron köprü restorasyonları ile tamamlanması sırasında yapısal bütünlüğün korunması amacıyla daha konservatif tedavi seçeneklerine yönelim artmıştır.

1955 yılında Buonocore'un asitle pürüzlendirme tekniğini uygulaması ve 1962 yılında Bowen tarafından BIS-GMA içeren kompozit rezinlerin tanıtılması ile, eksik dişlerin tedavisi için doğal diş, akrilik ya da kompozit rezin restorasyonların ağızdaki destek dişlere direkt olarak yapıştırılmasına dayanan adeziv köprüler denenmeye başlanmıştır.[1,2] Rochette 1973 yılında periodontal splint uygulaması yapılacak

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dişlerin delikli bir metal bant yardımı ile birbirine bağlanmasını ve tutuculuğun metal üzerinde hazırlanan delikler ile sağlanmasını önermiştir.[3] 1983 yılında Thompson, Livaditis ve Castillo[4-7] ise metal elektro-korozyonundan yararlanarak metal yüzeyinde mikro tutucu alanlar elde etmişler ve uyguladıkları bu protez serisini "Maryland Köprü" olarak tanımlamışlardır.

Genel anlamda adeziv köprüler; metal destekli adeziv köprüler, porselen seramik ile yapılmış adeziv köprüler ve fiberle güçlendirilmiş adeziv köprüler olmak üzere 3 gruba ayrılmaktadır.[8,9] Geleneksel adeziv köprülerde kullanılan kıymetsiz metal alaşımlarının neden olduğu korozyon ve alerjik reaksiyonlar biyolojik uyumu olumsuz olarak etkilemektedir.[10] Tam seramik adeziv köprüler ise; yüksek biyolojik uyumları, estetik üstünlükleri, diş dokularına yakın termal genleşme katsayıları, düşük ısı iletkenlikleri, elektrolitik korozyona dirençli olmaları nedeniyle tercih edilebilmektedir. Fakat gerilim kuvvetlerine karşı yeterli dirence sahip olmamaları ve kırılgan yapıları yaygın olarak kullanımlarını engellemektedir.[11,12] Geleneksel adeziv köprülerde tutuculuğun yanı sıra, estetik ve biyolojik uyum sorunlarıyla da karşılaşılması fiberle güçlendirilmiş adeziv köprülerin gelişimine yol açmıştır.[10]

Fiberle Güçlendirilmiş Adeziv Köprüler

Fiberle güçlendirilmiş kompozitlerin (FGK) sabit bölümlü protezlerde kullanımı 1990'lı yıllardan itibaren artış göstermiştir. Marjinal uyumlarının, mekanik ve estetik özelliklerinin iyi olduğu çok sayıda in vitro araştırmada belirtilmiştir. Günümüze kadar fiber ile güçlendirilmiş kompozitler ile ilgili birçok araştırma yapılmış ve rezin bağlantılı fiber ile güçlendirilmiş kompozitler kullanılarak yapılan köprüler metal destekli rezin bağlantılı köprülerin yerini almaya başlamıştır. Hem hasta üzerinde hem de laboratuvarda hazırlanabilmeleri sayesinde bugün diş hekimliğinin pek çok alanında kullanılabilmektedirler.[13,14] Geleneksel köprülerde daha invaziv diş preparasyonu hazırlanırken, adeziv sistemlerdeki gelişmelerle birlikte FGK'nın mekanik özellikleri de geliştirilmiştir ve bu gelişmelere bağlı olarak günümüzde, destek dişler üzerinde preparasyon yapmadan ya da minimum preparasyon yaparak daha konservatif tedaviler uygulanabilmektedir.[15,16] Ön ve arka grup dişlerin eksikliğinde fiberle güçlendirilmiş adeziv köprüler destek sert ve yumuşak dokuların sağlığı ve uyumunu koruyan konservatif ve kalıcı bir sabit protez çeşidi olarak kabul edilmektedir.[10]

Fiber, uzunluğu çapından 100 kat daha fazla olan, ince ve esnek lifli, silindirik bir yapıdır. Diş hekimliğinde kullanılan fiberler; karbon fiberler, aramid fiberler, polietilen fiberler ve cam fiberler olmak üzere 4 gruba ayrılmıştır.[17,18] Cam fiberler ise kullanım alanı en fazla olan fiber tipidir. Fiber ile güçlendirilmiş kompozitler ise rezin matriks ve fiber alt yapıdan meydana gelen materyal birleşimleridir.[16] Fiber ile güçlendirilmiş kompozitlerin mekanik özellikleri fiber ve polimer matriksin mevcut özelliklerinden; fiberlerin miktarı, yönü, yüzey genişlikleri ve pozisyonundan; rezin ile doyurulup doyurulmamalarından; polimer matrikse olan adezyonundan ve fiber-matriks yapının su emilim miktarından etkilenmektedir.[19,20]

Seramikler ve kompozit rezinler gibi dental alaşımlar homojen, uniform ve izotropik oldukları için, her yönde aynı fiziksel ve mekanik özellikleri göstermektedir. FGK'ler ise anizotropik ve heterojen yapıda oldukları için fiberlerin yerleşimine göre farklı mekanik ve fiziksel özellikler göstermektedir. FGK'ler dayanıklı ve rijit oldukları için protetik restorasyonlarda tercih edilmektedir.[21]

Mekanik ve fiziksel özelliklerinin iyi olmasına rağmen FGK'lerin elastik modülüne ve restorasyonun sertliğine dikkat etmek gerekir. Metal destekli seramiklerde olduğu gibi FGK'lerde de üst yapının gerilme direnci alt yapıdan daha düşüktür. Bu nedenle mekanik sorunlar kompozit-fiber ara yüzünde veya kompozit içersinde oluşmaktadır.[22] Yokoyama ve ark.[23] restorasyonların fonksiyonel açıdan sağlıklı ve uzun ömürlü olması için mekanik özellikleri uygun olan rezin simanlarla birlikte kullanılmasını önermişlerdir.

Fiberle güçlendirilmiş adeziv köprüler geleneksel restorasyonlara göre daha biyouyumlu ve estetiktir. Konservatif olmaları, manipülasyonlarının kolay olması, oluşabilecek küçük kırıkların tamir edilebilir olması ve tekrar tekrar polisajlanabilmeleri nedeniyle tercih edilirler. Mumlama, revetmana alma ve döküm işlemi olmadığı için laboratuvar safhaları karmaşık değildir ve ekonomiktir. Yapımları tek veya en fazla iki seansta tamamlanır. Rezin simanla FGK restorasyon arasındaki bağlanma dayanımının, rezin simanla metal arasındaki bağlantı dayanımından daha fazla olduğunu gösteren çalışmalar vardır. Adeziv sistemlerin kullanımı marjinal sızıntıyı azaltır, tutuculuğu arttırır.[24,25]

Bütün bu avantajlarına rağmen dişsiz boşluğun uzun olduğu durumlarla ilgili uzun dönem klinik sonuçları olan çalışmalar yoktur. Klinik kron boyu yetersiz ise, bağlantı bölgelerinde sorun oluşabilir. Uygulanan kompozit rezin, aşınabilir ve renklenebilir. Ağız ortamıyla temas halinde kalan fiber lokal doku reaksiyonuna neden olabilir. Kompozitin tabakalama yöntemiyle uygulanmasına bağlı olarak polimerizasyonun gerçekleşemediği bölgelerde fiber-kompozit ara yüzünde ayrılmalar meydana gelebilir. Fiber materyalinin radyoopasitesi yetersiz olduğu için radyografik değerlendirmede sekonder çürük teşhisi koymak zorlaşır.[17,26,27]

Fiberle güçlendirilmiş adeziv köprüler; destek dişte minimal invaziv preparasyon yapılması isteniyorsa, metal alerjisi olan bireylerde, pulpa odasının geniş olduğu genç hastalarda, destek dişlerin prognozunun belirsiz olduğu durumlarda, büyüme ve gelişimin devam ettiği hastalarda, abrazyonun fazla olduğu hastalarda karşıt dentisyonu porselenin aşındırıcı etkisinden korumak için ve diş çekimi veya implant yerleştirilmesi sonrasında geçici protez olarak kullanılabilir.[15,26,28]

Fakat dişeti sıvısının kontrolünün iyi bir şekilde sağlanamadığı restorasyon marjinlerinin sulkus içerisinde yer aldığı durumlarda simantasyon zorluğu yaşanabilmektedir. Diş eksikliğinin fazla olduğu (iki veya daha fazla) bölgelerde uzun köprülerin yapılması gerekiyorsa ve destek dişlerin kron boyu 5 mm'den az ise kontrendikedir. Oral hijyeni kötü olan ve parafonksiyonel alışkanlığı olan hastalarda da tercih edilmemelidir.[15,26,28] Alkol kullanan hastalarda fiberin alkol ile teması polimer zincirini kırabileceği ve bu da kompozitin mekanik direncini azaltabileceği için tercih edilmesi önerilmez.[27,29,30]

Fiberle Güçlendirilmiş Sabit Protezlerin Yapımı

FGK altyapı materyalleri, metallere göre daha uygun estetik ve işlenebilme özellikleri göstermektedir. Metal altyapılardaki estetik problemler büyük ölçüde ortadan kalkmaktadır. FGK polimer yapısı nedeniyle diş yapısına adeziv tekniklerle bağlanabilmektedir. Ayrıca FGK altyapı materyallerinin metal içermemesi alerjik reaksiyon riskini de oldukça azaltmaktadır. Bu protezlerde gövde olarak hastanın kendi dişi, prefabrike akrilik rezin diş ya da kompozit rezinden hazırlanan bir diş gövde olarak kullanılmaktadır.[31]

Fiberle güçlendirilmiş sabit bölümlü protezler ilk olarak Vallittu[31] tarafından sınıflandırılmıştır. Buna göre FGK ile yapılan sabit bölümlü protezler 4'e ayrılmaktadır: Dalgalı ya da tek yönlü cam fiber alt yapı ile hazırlanan tam kronlar, fiber alt yapı ile hazırlanan yüzey tutuculu rezin bağlı sabit parsiyel protezler (Maryland tarzı), fiber alt yapı ile hazırlanan inley ya da bölümlü kron tutuculu

protezler ve fiber alt yapı ile hazırlanan yüzey tutuculu ve tam kron-inley tutuculu sabit protezlerin kombine kullanıldığ hibrit sabit bölümlü protezler.[31,32] Destek dişlerde herhangi bir çürük veya restorasyon yoksa; yüzey tutuculu, çürüklerin ve/veya restorasyonların mevcut olduğu durumlarda inley tutuculu, destek dişlerde hem çürük ve/veya restorasyonun bulunduğ ek olarak dişin bukkalinden/lingualinden destek fiber yerleştirildi durum hibrit tutuculu olarak tanımlanmıştır.[31]

Vallittu ve ark.[31] birinci küçük azı dişi eksik olan hastaya, destek dişlerine herhangi bir preparasyon yapmadan FGK restorasyon uygulamış ve 5 yıllık takip sonucunda herhangi bir problem yaşanmadığını belirtmiştir. Heuman ve ark.[33,34] ise yaptıkları çalışmalarda destek dişlerden inley kavite ile tutuculuk sağladıkları, hibrid (bir dişe inley kavite-diğer dişe yüzey) tutuculuk sağladıkları ve sadece yüzeyden destek alan FGK rezin köprüler hazırlamışlardır. Karşılaştırma sonucunda ek mekanik tutuculuğun anterior ve posterior FGK rezin köprülerin uzun dönem başarısını değiştirmediğini bildirmişlerdir.

Freilich ve ark.[15] ise FGK alt yapı ile sabit bölümlü protezleri restorasyonun hazırlanma şekline göre; hasta başında yapılanlar ve laboratuvar ortamında yapılanlar olmak üzere iki grupta ayırmıştır.

Hasta Başında Yapılan Fiberle Güçlendirilmiş Adeziv Köprüler

Hasta başı uygulamanın, FGK restorasyonlar için en ideal uygulama şekillerinden biri olduğu bildirilmektedir. Hem anterior grup dişlerde hem de posterior grup dişlerde uygulanabilen bu teknik hızlı ve estetiktir.[32] Tek seansta bitirilebildiği için geçici restorasyona ihtiyaç duyulmaz. İmplant planlanan hastalara geçici protez olarak uygulanabileceği gibi, daimî restorasyon olarak da kullanılması mümkündür. Direkt yöntemle FGK köprü yapımında rezinle doyurulmuş fiberler tercih edilmelidir veya kullanılan fiberler rezin ile doyurulmalıdır, üst yapı için kullanılacak kompozitler hibrid ya da mikrofil doldurucu olmalıdır.[17,35] Hastanın kendi dişi, prefabrike akrilik rezin diş ya da kompozit rezinden hazırlanan bir diş gövde olarak kullanılabilir. Hastanın kendi dişi kullanıldığında sonuçlar hasta motivasyonu açısından daha olumludur.[16,36]

Direkt yöntemle yapılan FGK köprüler uygulanmadan önce komşu destek dişlerde; anterior restorasyonlar için lingual, posterior restorasyonlar için okluzal yüzeylerde inley kaviteler açılır. Eksik dişlerin restorasyonu için kullanılacak gövdeler kompozit fiberler yardımıyla bu dişlere bağlanmaktadır. Restorasyon geçici amaçla kullanılacaksa ve yeterli interokluzal mesafe varsa preparasyon yapılmaması önerilir.[9,15]

Eskitaşçıoğlu ve ark.[37] üst lateralleri eksik olan ve implant restorasyonu planladıkları bir hastaya geçici restorasyon olarak fiber ile güçlendirilmiş köprü restorasyonu uygulamış ve gövde materyali olarak hastanın kendi dişlerini kullanmışlardır. Fiberle güçlendirilmiş adeziv köprüyü implantlar yerleştirildikten sonra adapte etmiş ve dört aylık süre sonunda fiber köprülerin destek dişle mevcut bağlantısını ayırarak implant üstü protez aşamalarına geçmişlerdir. Bu süre içerisinde fiber köprülerde herhangi bir başarısızlığa rastlamamışlardır.

Van Heumen ve ark.[33] yaptıkları çalışmada fiberle güçlendirilmiş rezin kompozit materyal ile hazırlanan 3 üyeli posterior sabit protezlerin uzun dönem klinik başarısını değerlendirmişlerdir. Yetmiş yedi hasta çalışmaya dahil edilmiş ve posterior bölgede 96 restorasyon hazırlanmıştır. Restorasyonlar yüzeyel tutucu, 2 inley tutucu ve tek tarafı yüzeyel diğer tarafı inley tutucu (hibrit) olacak şekilde 3 farklı formda hazırlanmıştır. Fiber materyali olarak Stick Resin (Stick Tech Ltd, Turku, Finlandiya) kullanılmıştır. Hastalar yılda bir kez olmak üzere 5 yıl boyunca kontrole çağırılmıştır. Çalışmada yer alan 11 hasta çeşitli nedenlerle klinik kontrollere gelmemiştir. Yirmi sekiz vakada kırık, delaminasyon veya desimantasyon gözlenmiştir. Buradaki restorasyonlardan 20 tanesi onarılmış sonrasında 5 vakada tekrar başarısızlık görülmüştür. Tek destek dişte delaminasyon (%52) ve desimantasyon (%28) onarılabilir komplikasyonlardan en sık rastlananıdır. Alt yapı kırığı (%38) ve delaminasyon (%20) ise en sık karşılaşılan başarısızlık sebepleridir. Bir vakada gövdede delaminasyon ve kırık gözlenirken; 3 vakada destek dişte deleminasyon ve kırık gözlenmiştir. Bu vakalardan 2'si başarılı bir şekilde onarılmış, 1 vakada başarısız olunmuştur. Sonuç olarak 5 yıllık süreçte fiberle güçlendirilmiş kompozit materyal ile hazırlanan 3 üyeli posterior sabit protezlerin klinik başarısı %71 ve sağ kalım oranı %78 olarak belirlenmiştir. Desimantasyon komplikasyonu sadece yüzeyel destek sağlanan restorasyonlarda görülmüştür. En sık karşılaşılan başarısızlık nedenleri delaminasyon, desimantasyon ve alt yapı kırığı olmuştur.

Goguta ve ark.[38] anterior ve posterior dişlere uygulanan FGK restorasyonların sağ kalımını araştırdıkları çalışmada 23 hastaya direkt yöntemle 23 FGK restorasyon uygulamışlardır. Çalışmada fiber materyali olarak önceden doyurulmuş cam fiber (ever-Stick C&B, Stick Tech, Turku, Finlandiya) kullanılmıştır. Posterior restorasyonlar iki dayanak dişe kavite açılarak inley tutuculu olarak hazırlanırken, anterior restorasyonlar bir dayanak diş inley tutuculu bir dayanak diş yüzey tutuculu olacak şekilde hazırlanmıştır. 6 yıllık takip sonucunda inley tutuculu FGK restorasyonların sağ kalım oranı %94,7 bulunurken inley-yüzey tutuculu restorasyonların sağ kalımı %25 olarak bulunmuştur. Bunun olası sebebi fonksiyon esnasındaki okluzal kuvvetler ve bruksizm olarak belirtilmiştir. Çalışmanın sonuçlarına göre uzun dönem takipte inley tutuculu FGK restorasyonlar çiğneme dayanımı ve estetik açıdan en iyi minimal invaziv tedavi seçeneğidir.

Erken M.'nin[9] yaptığı çalışmada, mandibulada veya maksillada anterior veya posterior bölgede tek diş eksikliğinin bulunduğu 58 kadın, 47 erkek hastaya 69 anterior, 36 posterior direkt kantilever tarzda restorasyon uygulanmıştır. Çalışmada cam fiber materyali olan (ever-Stick C&B, Stick Tech, Turku, Finlandiya) kullanılmıştır. 1 yıllık takip sonucunda 4 adet restorasyonda tutuculuk kaybı olduğu tespit edilmiştir. Bu restorasyonlardan 3 tanesi aynı yöntemle restore edilirken, diğeri üç üyeli sabit bölümlü protez ile değiştirilmiştir. Bu restorasyonların sağ kalım süresi ortalama 359 gün olarak bulunmuştur ve restorasyonlarda en çok karşılaşılan başarısızlık tipi, kompozit materyalde oluşan kırıklardır. Fiber alt yapının kırılması destek dişe kavite açılmayan durumlarda daha yaygın gözlenmiştir. Uygulama sırasında ve sonraki günlerde ya da kontrol seanslarında hiçbir hastada post-operatif hassasiyet şikâyeti gözlenmemiştir. Yapılan başka bir çalışmada ise, dört hastada gözlenen post-operatif hassasiyet 1 hafta ile 2 ay arasında ortadan kalkmıştır.[39]

Üç üyeli inley destekli rezin ile yapıştırılan SBP'lerde fiber materyalinin arttırılması restorasyonun dayanımını da arttırmaktadır. Ancak alt yapı gereğinden kalın yapılırsa onu kaplayacak olan kompozit ince kalacağından restorasyon yine dayanıksız hale gelecektir. Yapılan bir çalışmada hastada görülen fiber materyalindeki kırık, tamir edildikten kısa bir süre sonra tekrar kırılmıştır. Yapılan tamirin başarısız olmasının nedenlerinden biri, fiber materyalinin ve alt yapı materyalinin bağlantı şeklidir. Ayrıca tamirden sonra fiber materyali ve kompozit rezin arasında yetersiz bağlanma oluşabilmektedir.[15,17,40]

FGK restorasyonlarda görülebilen bir diğer komplikasyon ise destek dişte meydana gelen sekonder çürüktür. Kısa dönemli çalışmalarda sekonder çürüğe az ya da hiç rastlanmazken, araştırma süresinin uzamasıyla çürük oluşumunun da arttığı bildirilmiştir.[9,13]

Martínez ve ark.[41] 2020 yılında yaptıkları bir çalışmada anterior ve posterior bölgede tek diş eksikliği olan 21 hastaya 21 FGK restorasyon direkt yöntemle uygulamışlardır. Yeni bir teknik olan 'T' tekniği ile uygulama yapmak için ilk önce her iki arkın silikon kaydı ve interokluzal kapanış kaydı alınmıştır. Dayanak olarak kullanılacak dişlere inley kaviteler hazırlanmıştır. Hazırlanan kavitelere ilk olarak horizontal bir fiber (Rebilda® Post GT, VOCO GmbH, Cuxhaven, Almanya) yerleştirilmiş ve üzeri akışkan kompozit ile (Tetric Evo flow®, Ivoclar Vivadent AG, Schaanwald, Liechtenstein) kapatılmıştır. Daha sonra gövdenin geleceği bölgeye okluzogingival yönde dikey bir fiber materyali daha yerleştirilmiş ve 'T' formu elde edilmiştir. Gövdenin son şekli silikon anahtar yardımı ile nanohibrit bir kompozit (Tetric EvoCeram®, Ivoclar Vivadent AG Schaan, Liechtenstein) ile oluşturulmuştur. T tekniğinde embraşürlerin serbest bırakılıp ve yeterli interproksimal fırçalamaya izin vereceği, periodontal hastalık ve interproksimal çürüklerden kaçınılacağı belirtilmiştir. Restorasyonlar uzun dönem sağ kalımı açısından değerlendirilirken restorasyon şekli ve morfolojisindeki değişiklik, renk değişimi, sekonder çürük oluşumu ve kırık-ayrılma parametrelerine bakılmıştır. Yapılan takipte 54. ve 72. haftalarda 2 restorasyonda kayıp gözlenmiştir. Bir hastada ise 24. ayda desimantasyon meydana gelmiştir. 3 hastada 60., 72. ve 84. aylarda okluzo-bukkal ve okluzo-lingual bölgelerde kompozit kırığı meydana gelmiş, bu kırıklar ağız içinde tamir edilip cilalanmıştır. Bir başka hastada ise 72. ayda restorasyona polisaj yapılması gerekli olmuştur. Yapılan kontrollerde tüm restorasyonlarda emraşürlerde interproksimal fırçalamaya izin verecek bir açıklık olduğu, hastaların herhangi bir soğuk-sıcak hassasiyeti olmadığı ve çürük oluşumu gözlenmediği belirtilmiştir. Dokuz yıllık takip sonucunda kayıp gözlenen restorasyonlar dışında tüm restorasyonlar periodontal ve fonksiyonel açıdan kabul edilebilir bulunmuştur.

Laboratuvar Ortamında Hazırlanan Fiberle Güçlendirilmiş Adeziv Köprüler

Laboratuvarda yapılan FGK adeziv köprülerde alt yapı materyali olarak önceden doyurulmuş fiberler kullanılırken, üst yapı materyali olarak genellikle seramikle güçlendirilmiş kompozitler kullanılmaktadır.[15] Son yıllarda yapılan klinik çalışmalarda başarılı sonuçları bildirilen polietilen fiberlere ilgi artmıştır. Ticari olarak emdirilmemiş maddelerden polietilen dokuma (Ribbond: Ribbond ve Connect: Kerr) ve cam dokuma (GlasSpan: GlasSpan) şeklinde bulunmaktadırlar. Bu ürünler el ile şekillendirilmektedirler.[42]

Laboratuvar ortamında hazırlanan FGK restorasyonlar hasta başında hazırlanan FGK restorasyonlar gibi ışıkla polimerize olmakta fakat ek olarak ısıyla polimerizasyon işlemi, vakum ya da basınç uygulaması da yapılmaktadır. Bu ilave polimerizasyon işlemleri ile alt yapıya daha yüksek bir eğilme dayanımı kazandırılırken, üst yapıya daha fazla yüzey sertliği ile renk stabilitesi kazandırılmaktadır.[17,26]

FGK restorasyonlara başlarken anterior ve posterior bölgelerde preperasyon yapılacaksa mevcut restorasyonlar ve çürükler tamamen kaldırılmalıdır. Preparasyon marjini supragingival olmalıdır çünkü FGK restorasyonların başarısını etkileyen en önemli faktörlerden biri de simantasyon aşamasında sıvı kontrolünün sağlanabilmesidir. Bu nedenle simantasyon aşamasında rubber-dam kullanılması da önerilir.[15,43]

Cenci ve ark.[44] yaptıkları çalışmada posterior dişlere uygulanan fiberle güçlendirilmiş adeziv köprülerin uzun dönemdeki başarısını değerlendirmişlerdir. Seçilen 13 hastaya 22 posterior inley tutuculu adeziv restorasyon uygulanmıştır. İndirekt hazırlanan restorasyonlarda fiber materyali olarak polietilen fiber (Ribbond Co., Seattle, Wash, USA) kullanılmıştır. 8 yıllık takip sonucunda 22 restorasyonun 4'ünde kırık gözlenmiştir. Bu kırıkların tamamı destek ile konnektör arasındaki bağlantı noktasında gerçekleşmiştir. Ortalama sağ kalım ömrü 7 yıl olarak belirtilmiştir. Bu çalışmada değerlendirilen sonuçlar ve sağ kalım oranlarına bakıldığında posterior adeziv köprüler uzun dönemde başarılı bulunmuştur.

Bahadırlı ve ark.[45] nın çalışmasında üç hastaya eksik dişlerinin restorasyonu için fiberle güçlendirilmiş indirekt köprü uygulanması planlanmıştır. Hastaların okluzo-gingival mesafeleri ve bukko-lingual kret kalınlığı değerlendirilmiştir. Bir hastada destek olacak dişlerde kompozit dolguların bulunması nedeniyle inley tutuculu köprülerin hazırlanması uygun bulunmuştur. İkinci ve üçüncü hastada ise insizo-gingival mesafenin yeterli olması nedeniyle herhangi bir preperasyon yapılmamıştır. Polivinil siloksanla ölçü alımını takiben laboratuvar ortamında cam fiber alt yapı (Dentapreg PFM, ADM, Brno, Çek Cumhuriyeti) üzerine kompozit rezinle (Filtek Ultimate, 3M ESPE, St. Paul, MN, A.B.D.) restore edilmiş restorasyonlar hazırlanmıştır. Hastaların 6 ay ve 1 yıllık takiplerinde restorasyonlar mekanik, fonksiyonel ve estetik açıdan başarılı bulunmuştur.

Kim ve ark.[46] nın yaptıkları çalışmada ise 44 yaşındaki bir hastaya implant ve köprü protezi tedavi seçeneklerini reddetmesi nedeniyle tek üye fiberle güçlendirilmiş anterior adeziv köprü restorasyonu planlamıştır. Hastadan çekim öncesi bir tanı modeli elde edilmiştir. Dişin atravmatik bir şekilde çekimini takiben, prefabrik geçici kompozit bir pontik, çekim boşluğuna yerleştirilmiştir. Model üzerinde hastanın kendi dişi referans alınarak, ilgili bölgenin uzunluğuna uygun olarak kesilip hazırlanmış fiber materyali üzerine (FibreKor, Jeneric/Pentron Inc., Wallingford, Calif, USA) kompozit materyali kullanılarak (Filtek Z350 XT, 3M ESPE, St Paul, Minn, USA) bir pontik elde edilmiştir. 2 haftalık yumuşak doku iyileşmesini takiben hasta kliniğe tekrar çağrılmıştır. Fiberin adaptasyonu için komşu dişlerin lingual bölgesinde mine düzeyinde aşındırma yapılmıştır. Hazırlanan restorasyon akışkan kompozit (Aelite Flow, Bisco Inc.) kullanılarak diş yüzeyine adapte edilip, açıkta kalan diş dokusu aynı kompozit materyali ile kapatılmıştır. 1 yıllık takipte restorasyon estetik ve fonksiyonel açıdan başarılı bulunmuştur.

Kumbuloğlu ve ark.[47] yaptıkları çalışmada 134 hastaya indirekt yöntemle 175 anterior FGK restorasyon uygulamışlardır. Tüm restorasyonlar model üzerinde cam fiber (ever-Stick C&B, Stick Tech, Turku, Finlandiya) materyali kullanılarak yapılmıştır. 7,5 yıllık gözlem süresi boyunca 13 restorasyonda başarısızlık gözlenmiştir. Bir restorasyonda onarımı mümkün olmayan kırık meydana gelirken, 8 restorasyonda kısmi desimantasyon ve 4 restorasyonda da veneer kompozitinde ayrılma meydana gelmiştir. Onarımı mümkün olmayan kırık dışında tüm restorasyonlar onarılmış ve tekrar simante edilmiştir. Çalışmada restorasyonların sağ kalım oranı %97,7 olarak bulunurken başarısızlık oranı %1,73 olarak belirtilmiştir. Hiçbir vakada sekonder çürük gözlenmemiştir. Çalışmanın sonuçları değerlendirildiğinde en sık gözlenen başarısızlıklar restorasyonun desimantasyonu ve veneer kompozitinin ayrılması olarak belirtilmiştir.

Aktaş ve ark.[48] 17 hastaya 17 restorasyon uyguladıkları çalışmada indirekt, anterior yüzey tutuculu FGK restorasyonların

performansını değerlendirmişlerdir. Tüm restorasyonlar alçı model üzerinde, tek yönlü E-cam fiberler (Interlig, Angelus, Londrina, PR, Brazil) ile rezin kompozit (Gradia, GC, Tokyo, Japan) kombinasyon halinde kullanılarak bir yapılmıştır. 34,6 aylık ortalama gözlem süresinde teknik (kompozitin ayrılması, debonding veya diş/restorasyon kırığı) ve biyolojik (çürük) başarısızlıklar değerlendirilmiştir. Toplamda, 5 restorasyonda başarısızlık gözlenmiş, 2 restorasyonda veneer kompozitinde ayrılma, 3 tanesinde desimantasyon meydana gelmiştir. Sağ kalım oranı: %70,5 olarak bulunmuştur. Bir restorasyon yeniden yapılmış diğer tüm restorasyonlar ise onarılmıştır. Restore edilen dişlerin hiçbirinde sekonder çürük, diş kırığı ve endodontik komplikasyon gözlenmemiştir. 4 restorasyonda polisaj ve cila gerektirmeyen hafif renk değişikliği gözlenmiştir. Bu çalışmanın sonuçlarına göre cam fiber ile güçlendirilmiş 3 üyeli yüzey tutuculu anterior restorasyonlar yarı kalıcı bir tedavi yöntemi olarak önerilmiştir. Deneyimlenen başarısızlıkların desimantasyon veya veneer kompozitinin delaminasyonuna bağlı olduğu belirtilmiştir.

SONUÇ

Sonuç olarak, fiberle güçlendirilmiş adeziv köprüler; anterior veya posterior bölge tek diş eksikliklerinde, destek dişlerde preperasyon yapılarak veya yapılmaksızın güvenle uygulanabilir. İlgili literatürler incelendiğinde bu restorasyonların diş ve çevre dokularının sağlığını olumsuz etkilemediği görülmüştür. Restorasyonların estetik başarısı yüksek bulunmuştur. İmplant değerlendirilmesi öncesi, büyüme ve gelişimi implant restorasyonuna uygun olmayan hastalarda geçici süreler için güvenle kullanılabilmektedir. Bunun yanı sıra alveol kretin iyi değerlendirildiği; insizo-gingival yüksekliğin ve bukko-lingual kalınlığın yeterli olduğu vakalarda daimî sabit bir restorasyon olarak da tercih edilebilir. Hasta seçim kriterleri özenle yapılmalı, okluzyon ve hasta alışkanlıkları dikkatle değerlendirilmelidir. Endikasyona uygun olarak hazırlanan restorasyonlar sağ kalım süresi ve hasta memnuniyeti açısından başarılı bulunmuştur. Bu kriterlere dikkat edilmeyen durumlarda, klinik sonuçların farklılık gösterdiği bildirilmektedir.

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Bitkisel İçerikli Diş Macunlarının Antibakteriyel Etkileri ve Bu Etkilerin Belirlenme Yöntemleri

Antibacterial Effects of Herbal Toothpastes and Methods of Determining These Effects

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ÖZ

Diş çürüğü en sık görülen, çiğneme ve estetik görünümü olumsuz etkileyebilen, yıkıcı, multifaktöriyel bir hastalıktır. Çürüğü önlemede mekanik ve kimyasal plak kontrolünün büyük bir öneme sahip olduğu bilinmektedir. Mekanik temizliğin esas olduğu ağız bakımında başta diş macunları olmak üzere çeşitli kimyasal içerikli ürünlere alternatif antibakteriyel etkili ürün arayışı devam etmektedir. Son dönemlerde bitkisel içerikli diş macunları bu amaçla sıklıkla kullanılmaktadır.

Bitkilerin çürüğe karşı antibakteriyel etkilerinin araştırılması yeni bir konu alanı oluşturmuştur. Diş hekimliğinde uzun zamandır oral hijyeni sağlamak ve geliştirmek için çeşitli bitkisel ürünlerin etkisi araştırılmaktadır. Bu derlemede bitkisel içerikli diş macunlarının antibakteriyel etkilerinin yanı sıra, sık kullanılan bitkisel ekstraktların etkileri, işlev gösteren içerikleri ve kullanımları değerlendirilmiştir.

Anahtar Kelimeler: Diş çürüğü, antibakteriyel etki, bitkisel diş macunu, *Streptococcus mutans*

ABSTRACT

Tooth decay is the most common, devastating, and multifactorial disease that can affect chewing and aesthetic appearance negatively. It is known that mechanical and chemical plaque control are of great importance in preventing caries. In oral care, where mechanical cleaning is essential, the search continues for alternative antibacterial-effective products, especially toothpastes and products with various chemical-containing ingredients. Recently, herbal toothpastes are frequently used for this purpose.

Investigation of the antibacterial effects of plants against caries has created a new subject area. In dentistry, the effect of various herbal products has been investigated for a long time to provide and improve oral hygiene. In this review, besides the antibacterial effects of herbal toothpaste, the effects, functional ingredients, and uses of frequently used herbal extracts were evaluated.

Keywords: Tooth decay, antibacterial effect, herbal toothpaste, *Streptococcus mutans*

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GİRİŞ

Dünyadaki en yaygın sağlık sorunlarından biri olan diş çürüğü, diş dokusunu tahrip eden, çiğneme ve estetik görünümü olumsuz yönde etkileyebilen kronik, yıkıcı, bulaşıcı bir hastalıktır. Diş çürüğü, bu faktörlerin etkileşimi ve konakçı duyarlılığının bir sonucu olarak ortaya çıkar ve asidojenik bakteriler, sükrozu substrat olarak kullanırlar. Diş çürüğünün epidemiyolojisi hakkındaki kanıtların çoğunluğu, *Streptococcus mutans*'ın çürük oluşumundaki en etkili karyojenik bakterilerden biri olduğunu göstermektedir. Son yıllarda, özellikle gelişmiş ülkelerde çürük insidansında azalma görülmesine rağmen ülkemizde hala çocuk ve genç erişkinlerde büyük bir sağlık sorunu olarak güncelliğini korumaya devam etmektedir.[1-4]

Mekanik plak temizliği, ağız hijyen kontrolü için oldukça önemlidir. Diş macunları mekanik plak temizliğine yardımcı olarak önerilmektedir. Bu uygulamadan beklenen; dişeti sağlığının korunması, çürükle mücadele, ağız kokusunun giderilmesi, fırsatçı mikroorganizmaların ortaya çıkmasının önlenmesi, dentin hassasiyetinin engellenmesi ve dişlerin beyazlatılması gibi etkiler olabilmektedir. Tüm bu etkileri

sağlayabilmek için diş macunlarının içeriğine çeşitli ilaveler yapılmıştır. Antibakteriyel etkili maddeler, macunlar içerisine katılarak diş eti hastalıkları ve çürükleri önlemeyi hedeflemektedir. Üretici firmalar yeni ürünleri kullanıma sunarken hem kimyasal içerik oranını azaltmayı hem de çoklu etki ile başarı hedeflerini yükseltmeyi amaçlamaktadırlar.[1,5] Son dönemde, yüksek oranda antibakteriyel etki elde etmek için bitkisel içerikli ürünler de bu amaç ile diş macunları içerisinde sıklıkla kullanılmaya başlanmıştır.

Dental plağın kaldırılmasında diş macunları içerisinde kimyasal ajanlar 30 yıldan fazla süredir kullanım alanı bulmuştur. Bu ajanların başında ise fluor gelmektedir.[6,7,8] Diş macunları içerisine katılan kimyasal ajanlardan olan fluor, diş minesi remineralizasyonunu sağlamanın yanı sıra çürüğe karşı diş dokularını korumaktadır. Macunlar içerisine katılan diğer kimyasal ajanlardan bazıları ise klorheksidin, triklosan, sanguinarin, setilpiridinyum klorid olmuştur. Beyazlatıcı, aşındırıcı olarak macunlar içerisine katılan bazı kimyasal ajanların bir kısmı ise ayrıca antibakteriyel etki gösterdiği belirlenmiştir. Örneğin; SLS'nin (Sodyum Lauril Sülfat) yüzey enerjisini düşürerek ve protein denatürasyonu yaparak gösterdiği deterjan özelliğinin yanı sıra mikroorganizmaları da elimine ettiği bildirilmiştir.[9] Ancak antibakteriyel özelliği olan fluor, triklosan, SLS gibi bu kimyasal ajanların uzun süreli kullanımı olumsuz sonuçları da beraberinde getirmiştir. Fluorun genç yetişkinlerde fazla kullanımı fluorozise sebep olabildiğinden, fluoridli ürünlerin zararlı olabileceği düşünceleri artmıştır.[10] Triklosan, diş macunu, kozmetikler, sabunlar, deodorantlar, plastik şişeler gibi birçok ev eşyası içinde yaygın olarak bulunan antibakteriyel bir bileşiktir. Triklosanın endokrin hasarına sebep olduğu, hepatik katabolizmayı bozduğu, meme kanserine neden olduğu ile ilgili literatürde kanıta dayalı çalışmalar bulunmaktadır.[11,12] SLS'ler anyonik sürfaktan özelliği taşıyan kimyasallar olmaları nedeniyle şampuan, deterjan, diş macunu ve sabunlara nemlendirici, köpürtücü özellik kazandırır ve bu nedenle de bu ürünlerin içeriğinde yer almaktadır. SLS'nin dil üzerindeki fosfolipit tabakayı kırarak aftöz lezyonlara sebep olduğu yapılan çalışmalarla kanıtlanmıştır.[13,14,15]

Diş macunlarının içerisine eklenen kimyasal maddeler; ayrı ayrı incelendiklerinde başarılı görünse de ağızda kalma ve temas süreleri sınırlı olduğundan, ağız florasının korunmasında yetersiz kalabilmektedir.[5] Bitkisel içeriklerin diş macunları içerisine eklenmesiyle istenen antibakteriyel etkileri sağladıkları çalışmalarla ortaya konmaya başlamasını takiben üretici firmalar, devam eden sorunların önüne geçebilmek için diş macunlarının içine eklenen bileşiklerin ve ajanların etki şeklini, içeriğini ve türlerini geliştirerek ağızda kalma süresini ve etkinliğini artırmayı hedeflemişlerdir. Diş macunu pazarındaki bu ürün çeşitliliği durumu, ağız sağlığı için doğru diş macununu seçmek açısından hem kullanıcıda hem de diş hekiminde şüphe ve bilinmezlikler oluşturabilmektedir.

DİŞ MACUNLARININ YAPISI

Diş macunlarının yapısında her birinin etkisi ve görevi farklı olan birçok bileşen bulunmaktadır.[16] En sık kullanılan bileşenler aşındırıcılar, nemlendiriciler, deterjanlar, bağlayıcı maddeler, tat verici maddeler, terapötik maddeler, renklendirici ve koruyucu maddeler (Tablo 1) olarak sıralanmaktadır.[10] Bu komponentlerin bazılarının varlığı ya da diş macunları içerisindeki konsantrasyonları istenmeyen yan etkilere sebep olabilmektedir.[17]

Tablo 1. Diş macunu yapısındaki bileşenler[10]

Diş macunu içerisindeki bileşenler	%
Aşındırıcılar	20-40
Su	20-40
Nemlendiriciler	20-40
Deterjanlar	1-2
Bağlayıcı Maddeler	2
Tat Verici Maddeler	2
Terapötik Maddeler	5
Renklendirici ve Koruyucu Maddeler	1

Aşındırıcılar

Diş üzerindeki renklenmelere mekanik yolla etki gösteren bileşenlerdir. Dış kaynaklı renkleşmelerde etkilidir. Macun yapısına çoğunlukla dikalsiyum fosfat dihidrat, alümina, silika, kalsiyum karbonat sodyum bikarbonat katılmaktadır.[18]

Nemlendiriciler

Macun içerisindeki sıvı dengesini sağlayarak kurumasını önlemektedir. Gliserin, sorbitol, propilen glikol ve mannitol en yaygın kullanılan nemlendiriciler olarak bilinmektedir. Nemlendiriciler varlığında küf ve bakterilerin üremesi söz konusu olabileceğinden yapıya koruyucu bileşenlerin eklenmesi gerekmektedir.[19]

Bağlayıcı Maddeler

Diş macunu kıvamını ve stabilitesini kontrol etmeyi, diş macununun ağız ortamında kolay bir şekilde dağılmasını sağlamaktadırlar. Macunlar içerisinde kullanılan aljinat, magnezyum aluminyum silikat, sodyum karboksimetilseluloz bağlayıcı ajanlardan birkaçıdır.[20]

Tat Verici Maddeler

Diş macunu yapısına kullanım sırasında ağızda ferahlık, tazelik hissi bırakması için tatlandırıcılar ilave edilmektedir. Sakkarin diş macunu yapısına en sık eklenen tatlandırıcı olmakla birlikte nane, anason, limon, okaliptüs gibi tatlandırıcılar da diş macunu yapısına katılmaktadır.[21]

Sabunlar ve Deterjanlar

Macunlar içerisine dişleri temizlemek için deterjan ve sabunlar eklenmiştir. Diş fırçası ile diş fırçalama sırasında sabunların köpürücü etkisi yardımı ile debris ve plağın diş yüzeyinden uzaklaştırılması sağlanmıştır. Ancak sabunların bazı dezavantajları olduğu bildirilmiştir. Bu dezavantajlar; müköz membranı irrite etmeleri, tatlarının maskelenmesinin zor olması nedeniyle sıklıkla mide bulantısına sebep olmaları ve diş macunu içerisinde bulunan kalsiyum gibi maddelerle uyumsuz olmaları şeklinde bildirilmektedir.[22] Sabunlar dezavantajlarından dolayı diş macunlarının yapısından çıkarılmış ve yerini deterjanlar almıştır. Deterjanlar köpürtücü etkilerinden, antibakteriyel ve plak önleyici etkilerinden dolayı diş macunlarında kullanılmaktadır.[23]

Kimyasal Terapötik Maddeler

Macun içeriğine çok fazla farklı özellikte terapötik etkili maddeler ilave edilebilmektedir. Bu maddeler şu şekilde sınıflandırılabilir:

- Çürüğü durdurmaya yönelik maddeler,
- Plak oluşumunu engelleyici, antibakteriyel etkili maddeler,
- Diş taşı oluşumunu azaltmaya yönelik maddeler,
- Hassasiyeti önlemeye yönelik maddeler,
- Beyazlatmaya yönelik maddeler.[19]

Antibakteriyel Özelliğe Sahip Bitkisel Terapötik Maddeler

Geçmiş dönemlere ait bilgiler bitkisel içerikli antimikrobiyallerin yüzyıllardır gıda saklanması ve korunması maksadıyla kullanımı olduğunu göstermektedir. Bitkisel ekstraktların tedavi amacıyla ilk kullanımı M.Ö. 2700 yıllarına dayandığı, bu doğrultuda baharat ve uçucu yağların ilk olarak Mısırlılar tarafından kullanıldığı bildirilmektedir. 1880 yılında yapılan ilk çalışmalarda tarçın yağının şarbon hastalığına etkili olduğu belirtilmiştir.

Bitkisel ekstraktlar bitkinin çeşitli kısımlarından elde edilerek su, alkol veya uçucu yağlar içerisinde çözdürülerek hazırlanmakta ve çeşitli mikroorganizmalara karşı antimikrobiyal etki göstermektedir. Antimikrobiyal etkiden sorumlu bileşikler kumarin, terpenoit, alkoloit, fenolikler, flavonoitler ve organik asitlerdir.[24,25] Bitkilerdeki bu bileşiklerin antimikrobiyal etkisi farklı durumlardan etkilenebilmektedir. Özütün konsantrasyon değeri, kimyasal yapısı, çözücüsünün farklılığı gibi etkenler sonucu değiştirebilmektedir.

***Azadirachta indica* (Neem Ağacı)**
Alkaloid, glikozid, flavonoid, steroid ve tannik asit içermektedir. Bu zengin içerik antifungal etkide oldukça önemlidir. İçeriğindeki gallotannin, bakterinin glukan üretimini ve kümelenmesini engellemektedir. *Azadirachta indica* (neem) ekstraktı, periodontal ligamentte bulunan fibroblastlar ile biyouyum göstermesi sebebi ile periodontal hastalıkların tedavisinde oldukça etkili bir biçimde kullanılmaktadır. *S. mutans'a* karşı %50'lik konsantrasyonda antibakteriyel etkinlik gösterdiği çalışmalarda belirlenmiştir.[26,27,28]

***Salvadora Persica* (Misvak)**
Toplumda bilinen ismi 'Erak' olan bitkilerden elde edilir, oral hijyende önemli yer tutmaktadır. *Salvadora persica* (misvak) ekstraktlarının antibakteriyel, antifungal, antiplazmoidal etkileri gösterdiği bildirilmektedir. Bitki özütünde klor, kalsiyum, fluor, silika, bir sülfür bileşiği, C vitamini, taninler, saponinler, reçineler, fitosteroller, flavonoidler tiriterpenler, alkaloidler önemli bir miktarda olduğu araştırmacılar tarafından bildirilmiştir. İzotiyosiyanat bileşeni yüksek miktarda klorid içerdiğinden oral mikrofloradaki fırsatçı mikroorganizmaları inhibe etmektedir. *Candida albicans (C. albicans)*, *S. mutans*, *Aggregatibacter* a*ctinomycetemcomitans*, *L. acidophilus*, *Actinomyces naeslundii* ve *P. gingivalis* gibi bazı ağız patojenlerine karşı antibakteriyel, antifungal etkinlikleri kanıtlanmıştır. *Salvadora persica* (misvak)'ın antiplak özelliği ve fluorid, kalsiyum, C vitamini ve tannin gibi terapötik kimyasal maddeler salınımı da dahil birçok farmakolojik özellikleri olduğu belirtilmektedir. Diş taşı oluşumunu azaltabildiği bildirilmiştir. Bakterinin dişe yapışmasını engelleyerek antibakteriyel etkinlik oluşturmaktadır.[26,29,30]

***Mammea Americana* (Mamey Ağacı)**
Çiçeği, meyvesi terapötik amaçlı kullanılan bu bitki Güney Amerika'da yetişmektedir. Konvülsiyonu önlemekte, ateşi düşürmekte ve deri parazitleri üzerinde etkili olduğu bulunmuştur. *S. mutans* ve *P. gingivalis* üzerinde antibakteriyel etkinliği çalışmalarla gösterilmiştir.[26]

***Melaleuca alternifolia* (Çay Ağacı Yağı)**
Plağı azaltıcı olduğu, tükürükteki *S. mutans* miktarında azalma sağladığı, gargara olarak kullanıldığında diş eti enfeksiyonu ile mücadele ettiği ve *S. mutans* dahil olmak üzere ağızdaki birçok bakteri üzerine antimikrobiyal aktivite gösterdiği rapor edilmiştir. Zar geçirgenliğini bozarak bakterinin parçalanmasına sebep olmaktadır. Kimyasal içeriğindeki terpinen-4-ol ve 1,8-cineole sayesinde oral enflamasyonu azalttığı çalışmalarla gösterilmiştir. Antibakteriyel ve antifungal etkinliğinden dolayı bazı macunlarda kullanılmaktadır.[26,31,32] *Melaleuca alternifolia* (çay ağacı yağı) içerikli bir diş macunu ve farklı iki markanın diş macunlarıyla yapılan bir çalışmada *S. mutans*, *L. acidophilus* ve *C. albicans* mikroorganizmalarına karşı antimikrobiyal etkinlikleri açısından karşılaştırılmış ve ancak araştırma sonuçlarına göre *Melaleuca alternifolia* (çay ağacı yağı) içeren diş macununun en düşük antibakteriyel aktiviteye sahip olduğu bulunmuştur.[33]

***Camellia sinensis* (Yeşil Çay)**
Çayların ağız-diş sağlığına yararı olduğu kanıtlanmış, içeriğindeki tannik asitin *S. mutans* büyümesini önlediği ve spesifik flavanoidlerin, özellikle kateşinlerin, karyojenik bakterilerin büyümesini inhibe ettiği bildirilmiştir.[34,35]

Kimyasal içeriğindeki polifenol, kateşin, gallik asit ve flavinlerin antibakteriyel etkiden sorumlu olduğu düşünülmektedir. Diyetteki şeker tüketimine bağlı oluşabilecek diş çürüklerini azaltmaktadır. *Camellia sinensis* (yeşil çay)'da bulunan Epigalloctechin-3 gallate ağız kokusuna sebep olan merkaptanı ortadan kaldırmaktadır. Polifenoller sayesinde *C. albicans*'ın metabolik dengesini bozduğu çalışmalarla bildirilmiştir.[26,36]

***Apis Mellifera* (Propolis)**
Apis mellifera (propolis), bal arıları tarafından ağaçlardan ve çalılardan toplanan tomurcukların ve kabukları reçineli atılımlarının oluşturduğu bir üründür. *Apis mellifera* (propolis) yaygın olarak tıbbi amaçlı kullanılmaktadır. İmmünomodülatör özellikleri, HIV-1 replikasyonunun baskılanması ve immünoregülatör etki, sitotoksisite, serbest radikal süpürücü aktivite özelliklerinden antienflamatuar, antibakteriyel, antifungal ve antiviral faaliyetleri bildirilmiştir.[37]

Güçlü antimikrobiyal etkinliğinden ötürü *Apis mellifera* (propolis) "doğal antibiyotik" olarak adlandırılmaktadır. *Apis mellifera* (propolis) ülke piyasalarında kapsül, propolis tentürdiyotu, pastil, sprey, jel, krem, merhem, tablet, diş macunu, şampuan ve sakız formlarında bulunabilmektedir.

***Aloe Barbadensis* (Aloe Vera)**
Aloe barbadensis (aloe vera) bitkisi Liliaceae familyasının bir üyesidir. "Parlayan acı madde" anlamına gelen "Alloeh" sert yeşil renktedir, her biri iki parçadan oluşan mızrak şeklinde yaprakları tamamen farklı kompozisyonlara sahip maddeler üretir ve terapötik özelliktedir. *Aloe barbadensis* (aloe vera) jeli (veya müsilaj) olarak adlandırılan jöle benzeri bir malzeme içerir. Jel yaklaşık %98,5 su, geriye kalan %0,5-%1 katı maddeler vitaminler de dahil olmak üzere çok çeşitli bileşiklerden oluşan materyal A, C, E, B1 Vitamini (tiamin), niasin, B2 vitamini (riboflavin), kolin, folik asit, B12 vitamini ve fosfataz, alkalin fosfataz, amilaz, laktik dehidrojenaz ve lipaz gibi asidik enzimler içermektedir.[38]

Mentha piperita **(Nane);** antimikrobiyal, antienflamatuar, analjezik etkileri mevcuttur. *Foeniculum vulgare* **(Rezene);** transetol, fenşon, östrojel, kumatin, tannin, fenolik asitlerin esansiyel yağlarını içerir. Antifungal ve antibakteriyel özellikleri gözlenmiştir. *Salvia officinalis* (ada çayı), *Thymus vulgaris* (kekik), *Caryophylli aetheroleum* (karanfil), *Capsicum annuum* (biber), *Ocimum basilicum* (fesleğen), *Cocos nucifera* (hindistan cevizi yağı), *Eucalyptus globus* (ökaliptus), *Echinacea purpurea (*ekinezya) ve *Commiphora myrrha* (mür) sık kullanılan diğer içeriklerden bazılarıdır.

BİTKİLERDE ANTİMİKROBİYAL ETKİ GÖSTEREN BİLEŞENLER VE ETKİ MEKANİZMALARI

Fenolik bileşikler, organik asitler, uçucu yağlar bitkilerdeki antimikrobiyal etkiden sorumlu bileşikler olup bunlarda oluşabilecek değişiklikler antimikrobiyal etkiyi değiştirebilmektedir.[25]

Organik Asitler
Gıda endüstrisinde koruyucu olarak sıklıkla kullanılmakta olup, H^+ (Hidrojen) iyonu konsantrasyonunu etkilemektedir.[39,40,41] Antimikrobiyal etki organik asitin türüne, kullanım durumuna, pH'sına ve etki edeceği mikroorganizmanın yapısına göre farklılık gösterebilmektedir.[39]

Tablo 2. Farklı bitkisel içerikli ürünler ve meyvelerde bulunan fenolik bileşikler[44-49]

Bitkisel içerikli ürün	Belirlenen fenolik bileşikler
Aronya	*p-hidroksibenzoik asit, luteolin, naringenin, kaempferol, apigenin kafeik asit, klorojenik asit, siringik asit, p-kumarik asit, ferulik asit, sinapik asit, rutin, luteolin-glikozit, kersetin*
Beyaz ve kırmızı üzüm suyu	*Hidroksibenzoik asit, o-kumarik asit, ferulik asit, kateşin, epikateşin gallik asit, m-hidroksibenzoik asit, siringik asit, vanilik asit, hidroksisinnamik asit, kafeik asit, p-kumarik asit*
Elma	*Protokateşik asit, kateşin, epikateşin, kersetin, hiperin, florizin proantosiyanin, klorojenik asit, kafeik asit*
Pembe biber	*p-kumarik asit, gallik asit, protokateşik asit, siringik asit, vanilik asit, ferulik asit, p-hidroksibenzoik asit,*
Nar suyu	*Gallik asit, kateşin, epikateşin, ellajik asit, florizin, klorojenik asit, kafeik asit, ferulik asit, rutin, kersetin*
Papatya	*Neoklorojenik asit, klorojenik asit, kersetin-o-glikozit, ferulik asit, hesperidin, kersetin, apigenin kafeik asit, p-kumarik asit, ferulik asit-7-o-glikozit*
Portakal suyu	*Gallik asit, protokateşik asit, kafeik asit, klorojenik asit, p-kumarik asit, hesperidin, neohesperidin, didymin, apigenin ferulik asit, sinapik asit, narirutin, naringin*
Rezene	*Neoklorojenik asit, kersetin, apigenin klorojenik asit, gallik asit, kafeik asit, p-kumarik asit, ferulik asit-7-o-glikozit, kersetin-o-glikozit, ferulik asit, 1,5 dikafeolkuinik asit, hesperidin, sinnamik asit, rosmarinik asit*

Rahatlıkla hücre zarından geçebilen organik asitler, hücre dışı ortamı sitoplazmaya oranla daha düşük pH değerine getirip, kolaylıkla iyonlara ayrışmakta ve sitoplazmik pH değerini azaltmaktadır. pH'ın azalması ile beraber protein ve enzimlerin yapısı bozulmakta, zar geçirgenliği artmakta ve hedef mikroorganizma canlılığını kaybedebilmektedir.[39]

Fenolik Bileşikler

Bitkilerdeki sekonder metabolitlerdir (Tablo 2). Bitkisel içeriklerin her birinin kendine özgü lezzet ve renkte olması içerdiği fenolik içerik sayesindedir. Fenolik asitler ve flavonoidler olarak iki gruba ayrılırlar.[42]

Ortamın sıcaklık ve pH'sı ve ortamda mevcut olan yağ, tuz, protein bu metabolitlerin antimikrobiyal etkisini etkileyebilmektedir. OH^- (Hidroksil grupları) sayesinde fenolik bileşikler çeşitli mikroorganizmaları inhibe etmektedir. Bakterilerle etkileşerek, membran yapısını etkilemekte ve hücresel bileşenlerin hücre dışına geçisine sebep olmaktadır.[43]

Uçucu Yağlar

Çeşitli mikroorganizmalara karşı savunma amaçlı üretimi sağlanmaktadır. Bitkilerin çeşitli bölümlerinden su distilasyonu ile elde edilen aromatik bileşiklerdir.[50,51] Gıda endüstrisinde bozulmayı önlemek ve raf süresini uzatmak maksadıyla kullanılmaktadır.[52] Terpen, terpenoit, fenilpropanoit gibi bileşenleri içermektedir.[51] Koruyucu etkilerinden timol, öjenol ve karvakrol gibi bileşikler (Tablo 3) sorumludur.[5]

Antimikrobiyal etkiden sorumlu kısım yağ içeriğinde yer alan uçucu bileşenlerdir.[56] Çeşitli bileşenlerden oluşan uçucu yağlar tek bir bileşiğin aktivitesine bağlı değildir.[57] Antimikrobiyal etki mekanizması fenolik yapılarındaki monoterpenlerin hücre difüzyonunu etkilemesi, sitoplazmaya zarar vermesi, proton yörüngesini bozması ve hücre enerji sistemine verdiği zarar ile bağlantılıdır. Sitoplazmik zarın etkilenmesi hücre ölümüne neden olmaktadır.[57] Ayrıca hidrofobik yapısı sayesinde hücrelerin difüzyon kabiliyetini artırmaktadır. Bu etki, molekül ve iyonların hücre dışı ortama sızmasına ve hücre canlılığının yitirilmesine neden olmaktadır.[58] Antioksidan etkisi de bulunan uçucu yağlar lipid oksidasyonunu etkileyerek ürünlerin raf süresini uzatmaktadır.[59]

Bitkisel İçerikli Ürünlerin Antimikrobiyal Etkilerini Belirlemede Kullanılan Yöntemler

Bitkisel içerikli ürünlerin antimikrobiyal etkisini belirlemede farklı yöntemler kullanılmaktadır.[60] Antimikrobiyal etkinin belirlenmesinde çoğunlukla CLSI (Klinik ve Laboratuvar Standartları Enstitüsü) standartları kullanılmaktadır. Bu standartlara göre *in vitro* ortamda antimikrobiyal etkili maddenin, belli bir bakteri türüne karşı antimikrobiyal etkinliği belirlenmektedir. Dilüsyon ve difüzyon olmak üzere iki yöntemle değerlendirilmektedir.[61]

Dilüsyon testi, belli bir mikroorganizmayı öldürmek veya üremesini önlemek için gerekli en küçük konsantrasyon miktarını belirlemek için kullanılmaktadır. Tüp dilüsyon ve agar dilüsyon olarak iki yöntem kullanılmakta olup, tüp dilüsyon metodunda besiyeri olarak kalsiyum ve magnezyum içerikli Mueller- Hinton Agar yer almaktadır. Antimikrobiyal etkili maddeler önce çözücülerde hazırlanıp, sıvı besiyerinde seyreltilmekte, daha sonra test edilecek mikroorganizma antimikrobiyal maddenin farklı seyreltikleri bulunan tüplere ve antimikrobiyal madde olmayan kontrol tüpüne ilave edilmekte, sadece besiyeri olan tüp ise negatif kontrol şeklinde belirlenmektedir. Tüpler 35°C'de 24 saat inkübasyon süresi sonunda mikroorganizma gelişimi yönünden incelenip ve üremenin olmadığı, başka bir ifadeyle herhangi bir değişikliğin gözlenmediği en düşük konsantrasyon, MİK (Minimum İnhibisyon Konsantrasyon) değeri şeklinde ifade edilmektedir. Etken maddelerin MBK (Minimum Bakterisidal Konsantrasyon) değeri ise ilk aşamada eklenen test mikroorganizmalarının %99, 9 veya daha fazlasını öldüren konsantrasyon ya da yeni besiyerine alındıktan sonra herhangi bir gelişmenin olmadığı en düşük konsantrasyon olarak belirlenmektedir.[53]

Agar dilüsyon ve tüp dilüsyon benzer yöntemler olup tek farkın agar dilüsyonda hazırlanan antimikrobiyal maddenin Mueller- Hinton Agar içine eklenmesi ve iyice karıştırılan besiyerinin petrilere dökülmesidir. Antimikrobiyal maddenin farklı konsantrasyonları bulunmakta ve test edilecek mikroorganizma bu petrilere ekilmektedir.[61]

Difüzyon testi, agar yüzeyinde farklı yöntemlerle uygulanmaktadır. Antimikrobiyal maddenin, test edilen mikroorganizmanın ekildiği besiyerine difüzyonu prensibine göre belirlenmektedir. Belirli miktarlarda antimikrobiyal madde emdirilmiş kâğıt diskler, test mikroorganizmasının ekildiği katı besiyerlerine yerleştirilmektedir. Petrilerin inkübasyonu sonunda disk etrafında beliren zon milimetrik (mm) olarak ölçülmekte, sonuçlar standart inhibiyon zon tablolarına göre değerlendirilip çalışılan mikroorganizmanın antimikrobiyal maddelere karşı etkinliği saptanmaktadır.[62] Agar

Tablo 3. Bitkilerdeki uçucu yağ ve bileşenleri[49,51,54,55-58]

Bitki	Latince adı	Aktif bileşen kısmı %
Bergamot kabuğu	*Citrus bergamia* Risso	Limonen 59.2
Biberiye	*Rosmarinus officinalis L.*	1,8-Sineol 26
Havuç suyu	*Daucus carota L.*	Karatol 20.2
Karabiber	*Piper nigrum L.*	Piperin 33.5
Karanfil	*Syzygium aromaticum L.*	1,8-Sineol 4.6 Ojenol 0.73
Kekik	*Thymus vulgaris L.*	Timol 53.57
Kişniş meyvesi	*Coriandrum sativum L.*	Δ3-Karen 60.3
Kekik	*Origanum vulgare L.*	Karvakrol 67
Rezene	*Foeniculum vulgare L.*	*trans*-Anetol 56.4

difüzyonda ise, kültür içeren besiyerinde belirli genişlikte kuyucuklar açılıp, içerisine uçucu yağ ilave edildikten sonra petriler inkübe edilmektedir. Antimikrobiyal maddenin etkinliği, kuyucuk etrafında oluşan inhibisyon zonları ile belirlenmekte, disk difüzyon yöntemine benzer değerlendirilmekte ve oluşan zonunun çap genişliği ile doğru orantılı olarak artış göstermektedir.[53] E-test metodunda ise test edilecek mikroorganizma Mueller- Hinton Agar yüzeyine sürülmekte ve bu yüzeye belli bir antimikrobiyal madde içeren E- test şeritleri konumlandırılmaktadır. 35°C'de 18-24 saat inkübasyon süresi sonunda MİK değerleri, şerit etrafında beliren inhibisyon elipsinin şerit üzerindeki ölçekle çakıştığı noktaya göre belirlenmektedir.[61]

İn vitro testler korunması istenen durumlar için başlangıç test modellerini barındırmaktadır. Uygun testler ile *in vivo* ortamda gerçekleştirilebilecek olayları *in vitro* ortamda taklit etmek mümkündür. Bu testlerin basit olması, hızlı gerçekleşmesi, ucuz olması sıklıkla tercih edilmelerini sağlamıştır.[63]

Çoğu *in vitro* çalışmada yalnızca tek bir bitkisel ekstrakt incelenmiş ve antimikrobiyal özellik gösterdiği savunulmuştur. Ancak bu ürünlerin macun içerisinde kullanımında diğer deterjan ve abrazivlerle bir araya gelmesi ile aktif özelliklerini yitirebilecekleri, antimikrobiyal etkinliklerini kaybedebilecekleri ve bitkisel içerikli ürünlerin konsantrasyon miktarı ile antimikrobiyal aktivite arasında doğru orantılı bir ilişkinin olmadığı belirtilmiştir. Bitkisel ekstraktın macun içeriğindeki diğer maddelerle etkileşiminin antimikrobiyal etkinliği değiştirebildiği bildirilmiştir.[27,64] *İn vitro* çalışmalar olduğu haliyle *in vivo* ortama taşınamamaktadır. Etkinin değişebilmesi ve organizmaya yan etkilerinin olabilmesi açısından *in vivo* ortamda istenilen sonuca ulaşılması güçleşebilmektedir.

BİTKİSEL İÇERİKLİ DİŞ MACUNLARININ ANTİMAKTERİYEL ETKİLERİ İLE İLGİLİ YAPILAN ÇALIŞMALAR

Araştırmacılar, bitkisel içerikli diş macunlarının antibakteriyel etkileri ile ilgili yapılan çalışmalarda ağız patojenlerine karşı etkinliklerini ölçme üzerine yoğunlaşmışlardır.

Jain ve ark., *Aloe barbadensis* (aloe vera) jelin dört ağız patojenine (*S. mutans, Clostridium bacilli*, *A. actinomycetemcomitans, Staphlococcus aureus)*'a karşı antibakteriyel etkisini inceledikleri *in vitro* çalışmada 20 hastadan subgingival diş taşları ve periodontal, periapikal apseleri aspire ederek örnek almışlardır. *Aloe barbadensis* (aloe vera) yaprakları yıkadıktan sonra kalın epidermis tabakası kaldırılıp katı mukilagenöz jeli steril bir kapta toplamışlardır. 10 mL jeli 100 mL %2'lik Dimetil sülfoksitle (DMSO) karıştırıp 4°C'de saklamış, hazırlanan jeli disk difüzyon ve mikro dilusyon yöntemleri ile MİK değerlerini ve inhibisyon zonlarını ölçmüşlerdir. Kontrol grubu olarak Oflaksasin ve Siprofloksasin'in kullanıldığı çalışmada *Aloe barbadensis* (aloe vera) jelin %100 ve %50'lik konsantrasyonlarda antibiyotiklere yakın inhibisyon zon değeri oluşturduğunu, %25 ve %12,5 konsantrasyonlarında ise inhibisyon zonu oluşmadığını belirtmişlerdir. MİK'i en düşük *S. mutans* ve *Staph. aureus*'ta ölçmüşlerdir. Yüksek konsantrasyonlarda (>%50) alternatif antibakteriyel ajan olarak *Aloe barbadensis* (aloe vera)'nın ağız patojenlerine karşı kullanılabileceğini bildirmişlerdir.[65]

Cinnamomum verum (tarçın kabuğu), *Foeniculum vulgare* (rezene), *Ocimum basilicum* (fesleğen), *Mentha piperita* (bahçe nanesi), *Mentha spicata* (mızraklı nane), *Capsicum annuum* (siyah biber), *Citrus histriks* (kaffir limonu) ekstraktlarının kullanıldığı Wiwatanarattanabut ve ark.'nın çalışmasında bitkisel içerikler *S. mutans* ve *L. casei*'ye karşı antikaryojenik ve antiplak aktiviteleri agar difüzyon metoduyla değerlendirilmiştir. Bitkilerin yaprak, çekirdek veya kabuklarından elde edilen ekstraktlar hazır elde edilmiş, yapay tükürük inkubasyonu ve bakteri suşları eklenmiş, 1., 2., 4., 24. saatlerde ölçümler yapılmıştır. Pozitif kontrol grubu %2'lik klorheksidin gargarası, negatif kontrol grubu %10'luk Dimetil sülfoksit olarak kullanılmıştır. MİK ve MBK değerleri kaydedilmiş, *Capsicum annuum* (siyah biber) dışında tüm bitkisel ekstraktların antikaryojenik özelliğe sahip olduğu, en yüksek antimikrobiyal etkinin ise *Cinnamomum verum* (tarçın kabuğu)'na ait olduğu bildirilmiştir. Çalışmada kullanılan ekstraktlar *S. mutans*'a, *L. casei*'den daha etkin olduğu belirtilmiştir. Çalışma sonuçlarının literatürdeki diğer çalışmalardan farklılık göstermesinin sebebinin coğrafik bölge, hasat zamanı, ekstrakt prosedürleri, zaman, doz farklılığı olabileceği bildirilmiştir.[66]

Shaheen ve ark. Hindistan'da yaygın kullanılan 10 bitkisel diş macununun altı mikroorganizmaya (*S. mutans, S. sanguinis, A. viscosus, S. aureus, S. pyogenes, C. albicans*) karşı antimikrobiyal etkilerini araştırmışlardır. Difüzyon ve full strength yöntemlerini kullandıkları çalışmada *Streptococcus pyogenes*'in bitkisel diş macunlarına en duyarlı mikroorganizma olduğunu belirlemişlerdir. *Azadirachta indica* (neem), *Acacia arabica* (arabik akasya), *Mentha spicata* (mızraklı nane) bitkisel ekstraktlarını içeren Danthi Kanthi'nin *A. viscosus* dışında 1 : 1 konsantrasyonda ve full strengthte en etkili bitkisel macun olduğunu bildirmişlerdir. *Glycyrrhiza glabra* (meyan kökü), *Caryophylli aetheroleum oil* (karanfil yağı), *Mentha piperita* (nane), *Curcuma longa* (zerdeçal) bitkisel ekstraktlarını içeren Amar Premium *S. aureus* dışında beş mikroorganizmaya karşı geniş inhibisyon zonu oluşturduğunu, *Candida albicans*'a karşı Amar Premium'un önemli etki gösterdiğini ve *Salvia officinalis* (adaçayı), *Commiphora myrrha* (mür), *Eucalyptus globus* (ökaliptus), *Melaleuca alternifolia* (çay ağacı yağı), *Matricaria recutita* (papatya) bitkisel ekstraktlarını içeren Colgate Herbal'in *S. aureus* dışında diğer beş mikroorganizmaya karşı antimikrobiyal etkisi olduğunu belirtmişlerdir.[28]

Randall ve ark. bitkisel içerikli ve fluoridli diş macunlarının *in vitro S. mutans*'a karşı antibakteriyel etkilerini inceledikleri çalışmada, Avustralya'da popüler olarak kullanılan 16 adet diş macununu değerlendirmişlerdir. Agar difüzyon metodu kullanılan çalışmada macunların altısı bitkisel içerikli diş macunu olup ayrıca fluoridli içerikleri de incelemişlerdir. Negatif kontrol grubu PBS (phosphate buffer salin) ve pozitif kontrol grubu olarak da %0,25'lik klorheksidini kullanmışlardır. Fluoridli diş macunları içerisinden en yüksek antibakteriyel etki Colgate Total' de saptanmış olup, bu değerlerin fluorid konsantrasyonu ile doğru orantılı olmadığını, kullanılan bitkisel diş macunlarından *Eucalyptus globus* (ökaliptus), *Cinnamon Cinnamomum verum* (tarçın), *Mentha piperita* (nane) içeren Herbal Fresh ve *Carum petroselinum* (maydanoz), *Seed oil* (tohum yağı) içeren Macro'nun antibakteriyel etkinliğinin olduğunu belirtmişlerdir. NaF, SLS, triklosan, stannöz fluorid, sodyum monofluorofosfatı ayrı ayrı değerlendirmişler ve en geniş inhibisyon zonun stannöz fluorid içerikli macunda olduğunu (24,3 mm), macun içerisindeki SLS'nin triklosan ve klorheksidinden daha fazla antimikrobiyal özelliğe sahip olduğunu ve fluoridli diş macunların, fluorid içermeyenlere göre *S. mutans*'a karşı daha etkili olduğunu bildirmişlerdir.[67]

Tatikonda ve ark. bitkisel ekstrakt içeren ve içermeyen iki diş macununun plak ve gingivitis üzerine antimikrobiyal etkinliklerini klinik olarak karşılaştırdığı bir çalışmaya 35-43 yaş arası 30 kişi

dahil etmişlerdir. En az 20 doğal dişi olan ve sondalama derinliği 3 mm'den az olan bu hastalar iki gruba ayrılmış ve plak ve gingival indeks skorlarını ölçülmüştür. Gruplardan biri mentol, metil asetat, öjenol içeren Dabur Red isimli bitkisel diş macunu, diğeri ise fluorid ve triklosan içeren Pepsodent diş macununu kullanmışlardır. 30 günlük kullanım sonrası plak ve gingival indeks skorlarını çalışmanın ilk günüyle karşılaştırmışlar, her iki grubun da plak ve gingival indeks skorlarının birbirine yakın olduğunu, plak birikimini önleyebildiklerini ve gingivitis oluşumuna engel olduklarını belirtmişlerdir. İki grup arasında istatistiksel açıdan anlamlı farkın bulunmamasına rağmen, Dabur Red'in dental plağı kaldırmada triklosan ve fluorid içeren Pepsodent'e göre daha etkili olduğunu bildirmişlerdir.[68]

Bitkisel içerikli diş macunlarının plak ve gingivitis üzerine klinik ve biyokimyasal etkinliğini araştıran George ve ark., 18-65 yaş aralığında 30 kişinin katıldığı çalışmada fluorid içerikli Colgate ve *Matricaria recutita* (papatya), *Salvia officinalis* (adaçayı), *Commiphora myrrha* (mür), *Eucalyptus globus* (ökaliptus), sesquiterpene içeren Colgate Herbal diş macunlarını karşılaştırmışlar, çalışma başlangıcında gingival ve plak indekslerini ölçmüşler ve katılımcıların uyarılmamış tükürüklerini toplayarak pH değerlerini kaydetmişlerdir. 30 gün boyunca devam eden çalışmada günde iki kez diş fırçalama sürecini kontrol ve test gruplarında takip etmişlerdir. Colgate Herbal diş macununun içeriğinde antiinflamatuar etkisi olan *Matricaria recutita* (papatya); antibakteriyel, antifungal, antiviral etkileri olduğu bilinen *Salvia officinalis* (adaçayı); antiseptik ve yara yeri iyileşmesinde etkili *Commiphora myrrha* (mür); aroma verici ve antiseptik etkili *Eucalyptus globus* (ökaliptus) bulunduğunu belirtmişlerdir. Colgate Herbal macun grubu içinde plak ve gingival indeks skorlarında istatistiksel açıdan anlamlı olarak fark bulunduğunu, pH değerlerinde ise anlamlı farkın bulunmadığını belirtmişlerdir. Colgate grubunda ise plak ve gingival indeks skorlarında istatistiksel açıdan anlamlı fark bulunmamış, ancak asiditesinin değişiklik gösterdiğini bildirmişlerdir. Colgate ve Colgate Herbal macun grupları karşılaştırıldığında plak ve gingival indeks skorları arasında istatistiksel açıdan anlamlı bir farkın olmadığını belirtmişlerdir.[69]

Shanmugapriya ve ark. 18-25 yaş arası 30 sağlıklı bireyde ev yapımı bitkisel bir diş macununun antiplak etkisini karşılaştırmak için plak ve gingivitis skorlarını ölçen bir çalışma yapmışlardır. Gruplardan biri ev yapımı ve biri ticari macun kullanacak şekilde iki gruba ayrılan bireylerin tümüne Modifiye Bass Tekniği öğretilerek, bu yöntem ile dişlerini bir hafta düzenli olarak 3-5 dk fırçalamaları gerektiği belirtilmiştir. Ev yapımı macun içerisinde *Caryophylli aetheroleum oil* (karanfil yağı), *Cocos nucifera* (hindistan cevizi), *Mentha piperita oil* (nane yağı), su, sodyum bikarbonat kullanılırken, içeriğinde SLS, triklosan, kalay fluorid, *Mentha piperita* (nane) ve aluminyum oksit yer alan ticari bir macun kullandırılmıştır. Plak örnekleri alınmadan önce, benzer ve karşılaştırılabilir başlangıç plak seviyelerine getirmek için bireylerin 72 saat hiçbir şekilde dişlerini fırçalamamaları istenmiştir. Plak ve gingivitis skorları Quigley-Hein Plaque indeksine göre kaydedilmiştir. Macunlar rastgele olarak dağıtılmış, bir hafta kullanım süresi sonunda plak skorları belirlenmiş, yeni macun kullanılmadan önce bir hafta süre ile macunsuz fırçalatılmış, daha sonra 72 saat fırçalama işleminin yapılmaması gerektiği bildirilmiştir. Değiştirilen macunlarla bir hafta boyunca düzenli fırçalamaları sağlanmıştır. Çalışma süresi sonunda son plak skorları kaydedilmiş ve her iki macun da plak skorlarında azalma istatistiksel açıdan anlamlı bulunmuştur (P < ,001). Ticari macuna ait ortalama plak skoru 1,93 ± 1,52 iken; ev yapımı macuna ait ortalama plak skoru 2,35 ± 1,39 olarak kaydedilmiştir. Araştırmacılar tarafından ev yapımı hazırlanan *Caryophylli aetheroleum oil* (karanfil yağı), *Cocos nucifera* (hindistan cevizi yağı), *Mentha piperita oil* (nane yağı) bitkisel macunun etkili plak önleyici olarak kullanılabileceği bildirilmiştir.[70]

Türkiye'de bitkisel diş macunlarından *Calendula officinalis* (aynısefa) içeren Weleda, ksilitol, hindistan cevizinden derive edilmiş gliserin içeren Jack N'Jill, ksilitol, *Salvia officinalis* (adaçayı), *Mangifera indica* (mango) içeren Bioplante, ksilitol, *Aloe barbadensis* (aloe vera), *Foeniculum vulgare* (rezene), *Commiphora myrrha* (mür) içeren Urtekram, *Aloe barbadensis* (aloe vera), *Cocos nucifera* (hindistan cevizi), *Eucalyptus radiata* (ökaliptus) içeren Radius, *Melaleuca alternifolia* (çay ağacı) içeren Eurofresh, *Mentha piperita* (nane) içeren Logodent, *Eucalyptus globus* (ökaliptus), *Salvadora persica* (misvak) içeren Spumy, ksilitol, *Tillia cordata* (ıhlamur), *Lonicera caprifolium* (hanımeli), *Populus tremuloides* (titrek kavak ağacı) içeren R.O.C.S., *Aloe barbadensis* (aloe vera), *Lonicera caprifolium* (hanımeli), *Glycyrrhiza glabra* (meyan) içeren Splat, ksilitol, *Melaleuca alternifolia* (çay ağacı), *Salvadora persica* (misvak) içeren Naturalive, *Aloe barbadensis* (aloe vera), ksilitol içeren Azetabio ve Biosmile, *Salvadora persica* (misvak), *Aloe barbadensis* (aloe vera), ksilitol, *Melaleuca alternifolia* (çay ağacı) içeren Ersağ, *Melaleuca alternifolia* (çay ağacı), *Salvia officinalis* (adaçayı), *Caryophylli aetheroleum* (karanfil), *Eucalyptus globus* (ökaliptus), *Salvadora persica* (misvak), *Mentha piperita* (nane) içeren Agarta marka diş macunları bulunmaktadır.

SONUÇ

Bitkisel içeriklerin kullanımının kimyasal içeriklerin sebep olabileceği birçok yan etkiyi önleyebileceği düşüncesi ile uygun dozlarda geleneksel antimikrobiyaller olarak kullanımları ile ağız ve diş sağlığı açısından kazanılacak olumlu katkılar en doğal yol ile elde edilmiş olacaktır. Bitkisel moleküllerin ürün çalışmaları için kılavuz ilkelerin bildirilmesine ihtiyaç duyulduğu ve sentezlenmiş kanıtların kalitesinin düşüklüğü nedeni ile ağız hijyen ürünleri kullanımında bitkisel diş macunlarını fluoridli diş macunlarına alternatif olarak tavsiye etmek için henüz erken olduğu düşünülmektedir.

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Current Research in Dental Sciences

Case Report *Olgu Sunumu*

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Erosive Lichen Planus Affecting the Gums: A Case Report

Dişetini Etkileyen Eroziv Liken Planus: Vaka Raporu

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ABSTRACT

Oral lichen planus (OLP) is a more common autoimmune inflammatory disease than other dermatoses. It causes symptoms such as painful ulcers and a burning sensation, prompting the patient to seek help from a health-care provider. While it occurs clinically in various forms, the reticular form is the most common. Oral lichen planus is considered by many researchers to be a premalignant condition. The purpose of this case report is to discuss the clinical features of OLP.

Keywords: Malignant transformation, oral lichen planus, OLP etiology

ÖZ

Oral liken planus (OLP) diğer dermatozlara göre daha sık görülen enflamatuvar otoimmün bir hastalıktır. Ağrılı ülserler ve yanma hissi gibi semptomlar oluşturarak hastanın sağlık kuruluşuna başvuru yapmasına neden olmaktadır. Klinik olarak çeşitli formlarda karşımıza çıkarken en sık retiküler form görülmektedir. OLP'un pre-malign olduğu birçok araştırmacı tarafından kabul edilmektedir. Bu vaka raporunun amacı OLP' un klinik özelliklerini tartışmaktır.

Anahtar Kelimeler: Oral liken planus, malign transformasyon, OLP etyolojisi

INTRODUCTION

Lichen planus is a chronic inflammatory disease of unknown etiology that frequently affects mucous membranes, skin, genital mucosa, scalp, and nails. This disease was first described by Erasmus Wilson in 1869.[1] Women are affected twice as often as men.[2] Patients 50 years of age and older are more commonly affected.[3] Lichen planus affecting the oral mucosa is called oral lichen planus (OLP) and may occur alone or together with skin lesions. The incidence of OLP is 1.9%, which is more common than the cutaneous form (0.23%). On clinical examination, OLP can be divided into 6 types: papular, reticular, plaque-like, atrophic, erosive, and bullous types.[4] The most common type is the reticular pattern that appears as thin white lines known as Wickham's striae. The OLP may occur along with systemic diseases such as diabetes mellitus, hepatitis C, and hypertension. Lichenoid lesions can be triggered by various medications, such as antibiotics, antihypertensives, anti-inflammatories, and antimalarials. Metal restorations can also trigger lichenoid reactions in the adjacent oral mucosa.[5] Treatment of OLP is usually performed when erosive lesions or ulcerations are present. Before starting local or systemic treatment, it is important to eliminate all factors that may be responsible. Various therapeutic agents can be used in the treatment of OLP, including topical, intralesional steroid and systemic corticosteroids, immunosuppressants, retinoids, and immunomodulatory drugs.[6]

CASE PRESENTATION

A 52-year-old female patient was admitted to Kırıkkale University Faculty of Dentistry, Department of Periodontology, complaining of pain and redness of the buccal mucosa and gums. During history-taking, it was noted that the red lesions had been in the mouth for 1.5 years with no previous pain and that she suffered from type 2 diabetes. The patient was a nonsmoker. Intraoral examination revealed erosive lesions on the gums and Wickham's striae on the buccal mucosa (Figure 1).

Histopathologic examination and direct immunofluorescence examination by punch biopsy from the gingival area where the lesion was most severe were performed to make a definitive diagnosis (Figure 2).

Histopathological examination of the tissue revealed mucosal tissues, in which epithelial and connective tissues were seen separately. In the fragment belonging to the surface of the parakeratinized mucosal epithelium, degeneration and loss of basal layer cells were observed, and inflammatory cells were found to invade the epithelium. In the connective tissue fragment, lymphocytic infiltration is

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Figure 1. Image of redness on the patient's gums and Wickham's striae on the buccal mucosa.

present in the form of a band in the lamina propria. In the material sent for freezing, limited connective tissue was seen beneath the edematous epithelium. In the immunofluorescence studies performed, fibrinogen was focally positive, whereas C3, immunoglobulin G (IgG), IgM, and IgA were negative. As a result of clinical and histopathological examinations, the patient was diagnosed with erosive lichen planus. As part of periodontal treatment, the patient was recommended a mouth rinse with 0.2% chlorhexidine gluconate to remove calculus and train oral hygiene. The patient was recommended topical clobetasol propionat. for 2 weeks. After the application of topical corticosteroids, it was recommended not to eat or drink anything for at least 1 hour to allow the drug to remain on the surface of the lesion for a while. As a result of the treatments, the patient's burning or painful symptoms disappeared (Figure 3).

During regular follow-up, the lesions were found to recur after 6 months (Figures 4 and 5). The patient was consulted by the department of dermatology, and a follow-up examination was performed in our clinic.

Figure 2. The appearance after performing a punch biopsy.

Figure 3. The appearance 1 month after the application of topical clobetasol propionate.

DISCUSSION

Although the etiology is not fully known, the disease is thought to be caused by a specific antigenic mechanism or autoimmune response triggered by alteration of epithelial basal cells, as well as nonspecific mechanisms and multivariate factors. Antigen-specific mechanisms may include limited antigen presentation by lesional keratinocytes, including major histocompatibility complex (MHC) class I and MHC class II. Many nonspecific mechanisms may play a role, including heat shock proteins, reactive oxygen products, stress, and mast cell chemotaxis.[7] The incidence of the disease is higher than that of other dermatoses and is more common in older women than in men. It is said that the lesion can be precancerous and turn into a malignant lesion. In particular, OLP has a risk of transforming into oral squamous cell carcinoma, and various publications have reported that this risk ranges from 0-12.5%.[8] However, there are authors who do not consider lichen planus lesions to be malignant.[9]

There are factors such as human leukocyte antigen, dental materials, infectious agents (gram-negative anaerobic bacilli and

Figure 4. The control picture of the patient after 3 months.

Figure 5. The patient's control appearance after 6 months.

spirochetes), and stress that have various contributions to OLP. Oral lichen planus has been associated with diabetes, hypertension, hepatitis C virus, thyroid disease, celiac disease, and other immune-mediated diseases.[10,11] In support of the literature, type II diabetes is known to be present in our case. On the contrary, 3 months after receiving the diagnosis of erosive lichen planus, our patient was admitted to the Department of Internal Medicine for examination, and hypertension was diagnosed during the examinations. A case of Grinspan syndrome with the triad of OLP, diabetes, and hypertension has been described in the literature. Because drug treatment for diabetes and hypertension can cause lichenoid reactions on the oral mucosa, it has been questioned whether Grinspan syndrome is an iatrogenically induced syndrome.[10] The fact that our patient was diagnosed with hypertension following treatment with OLP suggests that the drugs he was taking could cause this. Diabetes and hypertension medications can cause lichenoid reactions, and treatment of OLP can also lead to iatrogenic hypertension. Our case presentation represents new information in the literature in this regard.

The areas most commonly affected by OLP are the buccal mucosa, tongue, lips, gums, floor of the mouth, and palate. A burning sensation in the oral mucosa is a common symptom. In erosive OLP, varying degrees of ulceration may occur. The periphery of the lesion can usually be demarcated by thin, white, radiating lines—Wickham's striae. Involvement of the gingiva in erosive OLP can lead to desquamative gingivitis, which is why pain and burning in the affected area make the patient symptomatic. In our case, the anterior gingival region is affected, which is frequently mentioned in the literature and is symptomatic. This clinical presentation is not only a specific presentation for OLP. A similar clinical presentation can occur in many diseases, such as cicatricial pemphigoid, lupus erythematosus, pemphigus vulgaris, and linear IgA dermatosis. In addition, conditions such as hormonal disorders, candidiasis, lichenoid lesions, and vulvovaginal-gingival syndrome should be considered in the differential diagnosis of oral erosive lichen planus.[12,13] Our definitive diagnosis was made by biopsy. In our case, direct immunofluorescence (DIF) was performed for the differential diagnosis of diseases of the pemphigus group (paraneoplastic pemphigus) and pemphigoid (mucous membrane pemphigoid).[14] Immunoglobulin G and C3 were negative. Antibodies raised against the cell surface of keratinocytes can be detected in the diagnosis of diseases of the pemphigus group. The detection of specific antibodies against the intermediate substance (matrix) in the tissue and serum of the pemphigus patient is necessary for a definite diagnosis. Immunofluorescence techniques are now one of the most important diagnostic methods for immunobullous diseases.[15] Intercellular IgA deposits are observed in 50% of cases of IgA pemphigus at DIF. In our case, IgA was negative for linear IgA in direct immunofluorescence.

The goal of treating symptomatic OLP is to relieve sore ulceration or a burning sensation. A staged approach should be adopted. There is limited evidence from randomized controlled trials on the exact efficacy of the various commonly used preparations. In addition to treatment, patients should be educated about the need for good oral hygiene, and all causes of mucosal trauma, such as inappropriate dentures, sharp points, and weak dental restorations, should be eliminated.[16] Patients should be educated that there is a very low risk of malignancy associated with OLP and that long-term surveillance is appropriate.[17] In our case, it was suggested that the dentures be replaced, but the patient stated that he would have this done later because he was working a lot.

When treating OLP, pay attention to the medications used. Since the cause of OLP is currently unknown, there are no specific preventive measures for this disease. Diseases associated with OLP should be carefully investigated. However, regular clinical follow-up should be performed to exclude the risk of malignancy. For early diagnosis of oral squamous cell carcinoma, long-term follow-up of patients with OLP is required. Follow-up intervals can be adjusted to 2 months or 12 months, depending on the patient.

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