



e-ISSN:1307-3540

ADO

Klinik Bilimler Dergisi Journal Of Clinical Sciences

► Cilt/Volume:14 • Sayı/Issue:2 • 2025

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ADO Klinik Bilimler Dergisi • Journal Of Clinical Sciences

14



Klinik Bilimler Dergisi

Journal of Clinical Sciences

Ankara Dişhekimleri Odası'nın bilimsel yayın organıdır.
Scientific publication of the Ankara Chamber of Dentists
Yılda üç kez yayınlanır/Published Three times a year

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26.05.2025

Cilt:14 - Sayı:2 e-ISSN:1307-3540

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Yazarlardan, göndermiş oldukları makalenin daha önce yayınlanmamış, yayına kabul edilmemiş veya herhangi bir dergide değerlendirme aşamasında olmadığını beyan etmeleri istenmektedir. Herhangi bir bilimsel toplantıda sunulan özetlerin gönderim sırasında belirtilmesi zorunludur. Yazarlar, gönderim ve hakem değerlendirmesi sürecinde makalenin tüm sorumluluğunu üstlenirler. Etik beyanı gerektiren ancak ETİK KURUL Kurum adı, karar tarihi ve kimlik numarası belirtilmeyen ORJİNAL ARAŞTIRMA MAKALELERİ değerlendirmeye alınmayacaktır. Yazarlar, tüm olgu sunumları ve gerekli tüm çalışmalar için imzalı bilgilendirilmiş onam aldıklarını belirtmelidir. Bilgilendirilmiş onamlar sisteme ayrı bir pdf dosyası olarak yüklenmelidir. Etik Beyannameler, Gereç ve Yöntem bölümünde Etik Kurul adı, karar tarihi ve kimlik numarası ile birlikte verilmeli ve sisteme ayrı bir pdf dosyası olarak yüklenmelidir. **Her makalenin benzerlik raporu ile birlikte mutlaka İngilizce proofreading sertifikasında sisteme pdf dosyası olarak yüklenmesi gerekmektedir.**

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Orijinal araştırma makalesi: Başlıklar, Özet (İngilizce ve Türkçe), Giriş, Gereç ve Yöntem, Bulgular, Tartışma, Sonuç, Teşekkür, Kaynaklar, Tablolar, Şekiller ve Şekil açıklamaları.

Olgu sunumu: Başlık (Uzun ve kısa), Özet (İngilizce ve Türkçe), Giriş, Olgu Sunumu, Tartışma, Sonuç,

Teşekkür, Kaynakça, Tablolar, Şekiller ve Şekil Açıklamaları

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b- Her paragrafta satır girintisi kullanılmalıdır.

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f- Kısaltma standart bir ölçü birimi olmadığı sürece, metinde ilk geçtiği yerde parantez içindeki kısaltmanın ardından açık bir şekilde belirtilmeli ve metin boyunca aynı kısaltma kullanılmalıdır.

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Başlık sayfası aşağıdakilerden oluşmalıdır:

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b- 5 kelimeyi geçmeyen kısa bir başlık. (İngilizce ve Türkçe)

c- Yazarların akademik dereceleri dahil tam adları. Yazarların bağlı oldukları kurum (şehir ve ülke dahil), soyadlarından sonra üst simge numarası verilerek adlar satırının altında belirtilmelidir.

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e- Sorumlu yazarın iletişim bilgileri (posta adresi, iş telefonu, cep telefonu numaraları ve e-posta adresi)

f- Makalenin türü (orijinal araştırma makalesi, editöre mektup, olgu sunumu...)

g- Özet ve ana metinde ayrı ayrı yer alan kelime sayısı (şekil açıklamaları, tablo başlıkları ve kaynaklar hariç), kaynak, şekil ve tablo sayıları.

h- Finansman kaynağı (hibe numarası, protokol numarası vb. belirtiniz)

i- Teşekkür (makalenin herhangi bir bilimsel etkinlikte daha önce sunulmuş olması)

j- Etik inceleme kurulu bilgilerini (tam ad, tarih ve numara) burada ve metinde belirtin. Onay belgesinin dijital kopyası, gönderim sırasında ayrı bir belge olarak sisteme yüklenmelidir.

k-Kayıt sitesi (örn., clinicaltrials.gov), kayıt numarası, kayıt tarihi ve internet bağlantısı (önerilen) dahil olmak üzere klinik araştırma kayıt bilgileri.

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Özet, makalede yer alan bilgileri yansıtmalı ve makalenin ana metninde yer almayan bilgileri içermemelidir. Özet, şu başlıklar kullanılarak yapılandırılmalıdır: Araştırma makalesi için Amaç, Gereç ve Yöntemler, Bulgular ve Sonuç; olgu sunumları için Giriş, Vaka raporu ve Sonuç. Teknik notlar ve editörlere mektupta herhangi bir başlık bulunmamalıdır.

Özet ve anahtar kelimeler hem İngilizce hem de Türkçe olarak sunulmalıdır. Anahtar kelimeler Medical Subject Headings (MESH: www.nlm.nih.gov/mesh/MBrowser.html) ve Türkiye Bilim Terimleri (TBT; <http://www.bilimterimleri.com>) arasından seçilmelidir. MESH indeksi Türkçe olup alfabetik sıraya göre listelenmeli ve noktalı virgülle (;) ayrılmalıdır. Anahtar kelimeler başlık ve özetten seçilmemelidir çünkü bunlar otomatik olarak indekslenir; bunun yerine ana metinden seçilmelidir.

GİRİŞ

Ana fikir ve önemi anlatılmalıdır. Hiçbir sonuca, tartışmaya ve veriye yer verilmemelidir. Bölümün son paragrafında çalışmanın amacı açıkça belirtilmeli ve varsa araştırma hipotezi verilmelidir.

GEREÇ ve YÖNTEM

Tüm ticari ürün ve cihazların menşei açıklanmalı ve ticari isimleri ve kaynakları belirtilmelidir (isim, üretici, şehir ve ülke).

Bu bölümde etik onay belirtilmelidir (onay alınan Etik Kurul'un tam adı, onay tarihi, onay numarası yazılmalıdır). Varsa, bilgilendirilmiş onam alındığı belirtilmelidir.

Gözlemsel veya deneysel çalışmalarda katılımcıların (hastalar, kontrol grupları dahil laboratuvar hayvanları) seçimine ilişkin dahil etme ve hariç tutma kriterleri açıklanmalıdır.

Bu bölümün son paragrafında, istatistiksel analiz ayrıntılı olarak açıklanmalıdır. İstatistik terimleri ve sembolleri tanımlanmalıdır. Kullanılan bilgisayar yazılımı belirtilmelidir.

BULGULAR

İstatistiksel bulgular rapor edilmelidir, ancak bunların tartışılmasından veya yorumlanmasından kaçınılmalıdır. Gerekiyorsa tablo, grafik veya illüstrasyonlardan yararlanılmalıdır. Bu bölümde gerekli ise alt başlıklar kullanılabilir.

TARTIŞMA

Araştırmanın bulgularını tartışılmalı ve diğer çalışmalarla uyumu veya uyumsuzluğu belirtilmeli ve çalışmanın sınırlılıklarına yer verilmelidir. Giriş ve sonuç bölümlerinde verilen bilgilerin tekrarından kaçınılmalıdır.

SONUÇ

Bu bölümde yazarlar çalışmanın sonuçlarını kısaca ve net bir şekilde sıralamalı ve çalışmanın temel mesajlarını belirtmelidir. İstatistiksel ayrıntılara yer verilmemelidir.

TEŞEKKÜR

Çalışma bir hibe ya da başka bir fonla desteklenmişse bu bölümde destekleyen kuruluşun adı ya da hibe numarası verilmelidir.

ÇIKAR ÇATIŞMASI

Herhangi bir çıkar çatışması olmadığı belirtilmelidir.

KAYNAKLAR

ADO Klinik Bilimler Dergisi'nde alıntılar etiketlenmesi Vancouver sistemine göre yapılır. Kaynaklar ana metinde üst simge Arap rakamlarıyla ardışık olarak belirtilmelidir. Tam referans listesi numara sırasına göre verilmelidir.

Dergilerin başlıkları MEDLINE için İndekslenen Dergiler listesinde kullanılan stile göre kısaltılmalıdır. (<http://www.ncbi.nlm.nih.gov/nlmcatalog/journals>)

Yayınlanmamış veriler veya kişisel iletişim referans olarak kabul edilmez.

Metinde alıntı yapma örnekleri:

...önceki bir çalışmada belirtildi.¹

...önceki çalışmalarda belirtildi.^{2,4,6,8}

Yılmaz⁹ tarafından yakın zamanda yapılan bir çalışmada şöyle bildirildi:

Yılmaz ve Akın tarafından yakın zamanda yapılan bir çalışmada¹⁰ şu rapor edildi:

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Standart dergi makalesi

1. Erkmen E, Şimşek B, Yücel E, Kurt A. Comparison of different fixation methods following sagittal split ramus osteotomies using three dimensional finite element analysis: Part 1: Advancement surgery-posterior loading. Int J Oral Maxillofac Surg 2005;34:551-8.

Altıdan fazla yazarlı standart dergi makalesi

2. Tüter G, Kurtiş B, Serdar M, Aykan T, Okyay K, Yücel A, et al. Effects of scaling and root planing and sub-antimicrobial dose doxycycline on oral and systemic biomarkers of disease in patients with both chronic periodontitis and coronary artery disease. J Clin Periodontol 2007;34:673-81.

Tez

3. Kayaoğlu G. Endodontik hastalık açısından Enterococcus faecalis'in Kahve ve direnç çıkışının incelenmesi [tez]. Ankara: Gazi Üniversitesi; 2007.

Kitap ve kitapta bölüm

4. Okeson JP. Management of Temporomandibular Disorders and Occlusion. 7th ed. St. Louis, Missouri: Elsevier Mosby; 2013. p. 171-174.

5. Alaçam A. Pedodontik Endodonti. Alaçam T, Editör. Endodonti. 1.baskı. Ankara: GÜ Yayınları; 1990. s.809-859.

TABLolar ve ŞEKİLLER

Tüm tablo ve şekiller ana metinde yer alma sırasına göre Latin rakamlarıyla ardışık olarak numaralandırılmalı ve ayrıntılı olarak tartışılmalıdır. Yazılarda tablo ve şekiller ana metnin sonunda Kaynaklar kısmından sonra verilmelidir.

Tüm şekiller yüksek kalitede JPG, PNG, PDF veya TIFF formatında olmalı ve gönderim sırasında ayrı bir belge ile yüklenmelidir. Histopatolojik görüntülerde kullanılan renklendirici ve büyüme miktarı belirtilmelidir.

Kişi görüntülerinin yer aldığı yazılarda, bunların kullanılması için yazılı izin alınmalı ve yazıyla birlikte sunulmalıdır.

Tablo hazırlanırken ADO Klinik Bilimler Dergisi'nde daha önce yayınlanmış makaleler örnek olarak alınabilir. Tüm tabloların tablonun üst kısmında bir başlığı bulunmalı ve birlikte yüklenmelidir. Kısaltmalar, istatistiksel bilgiler (p değerleri veya istatistiksel analiz yöntemi vb.) tablonun altına dipnot olarak verilmelidir. Gerektiğinde yıldız işareti veya üst simge kullanılmalıdır.

Bir yazıdaki tablo ve şekillerin toplam sayısı 6'yı geçmemelidir.

ÇIKAR ÇATIŞMASI FORMU (ICMJE FORMU)

Dosyanın tamamını indirmek için lütfen tıklayın.

TELİF HAKKI FORMU VE YAZAR SÖZLEŞMESİ

Makale dosyalarının yükleme aşamasında telif hakkı formu ve yazar sözleşmesini indirebilirsiniz.

ÖN DÜZELTME VE MAKALE İADE SÜRECİ

Sisteme yüklenen makaleler Editör Kurulu'muzun değerlendirmesi sonucu ilk olarak ön kontrole alınır. DergiPark sisteminde yazılı dergimiz yazım kuralları doğrultusunda makaleler incelenir. **Ön kontrolde 2 kez düzeltme isteği alması ve gerekli düzeltmelerin verilen süre içerisinde yapılmaması halinde, makale sorumlu yazara iade edilir ve hakem değerlendirme sürecine alınmaz.**

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14. Cilt 2. Sayı için deęerlendirilen taslak makaleleri bilimsel ve tarafsız gözle inceleyen ve aŐaęıda isimleri belirtilmiŐ olan hakemlerimize ve bütün danıŐma kurulu üyelerimize teŐekkür ederiz.

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Tuęgen ÖZCİVELEK

Zeynep ÖZTÜRK

Evaluation of the Relationship Between Dental History and Oral Care Habits with Dental Fear Among Dentistry Students

Diş Hekimliği Öğrencileri Arasında Dental Geçmiş ve Ağız Bakım Alışkanlıklarının Dental Korku ile İlişkisinin Değerlendirilmesi

Büşra Tosun^{1*}, Esmâ Demirtaş¹, Nuran Yanıkoğlu²

ABSTRACT

Aim: The aim was to compare the levels of dental fear among dentistry students both between classes and between preclinical and clinical periods and to investigate the relationship between dental fear and gender, dental history, and hygiene.

Materials and Method: 369 dentistry students participated in the study. The Kleinknecht Dental Fear Survey Scale (DFS) was used to measure dental fear levels. Demographic data such as class year, gender, smoking status, and dental history were collected in the first part of the survey. In the second part, students were asked about their dental hygiene habits and in the last part, dental fear scale questions were asked. Normality was assessed with the Shapiro–Wilk test. Mann–Whitney U, Kruskal–Wallis, and Linear by Linear Association tests were used for statistical analyses.

Results: The dental fear score of women (17.0 ± 18.1) was higher than that of men (12.3 ± 14.1). While the DFS score in the preclinical groups was 17.4 ± 18.7 , the DFS score in the clinical group was 10.2 ± 10.0 . While the dental fear score of those who visited the dentist less frequently was higher (45.6 ± 22.9), it was observed that the DFS score of the individuals decreased significantly as the frequency of tooth brushing increased ($p < 0.001$). The DFS score of those who brushed their teeth twice a day was lower than the other groups (9.3 ± 9.4). As the class year increased, improvement was achieved in oral hygiene habits.

Conclusion: Dental fear in dentistry students was found to be related to gender, education stage and oral hygiene habits. This study emphasizes the importance of strategies aimed at reducing dental fear, especially in the preclinical period and improving oral hygiene habits. Addressing dental fear in educational processes may contribute to the training of more conscious and confident dentists in the future.

Keywords: Dental anxiety; Dental education; Dental fear; Dentist visit; Oral health

ÖZET

Amaç: Diş hekimliği öğrencileri arasında hem sınıflar arası hem de klinik öncesi ve klinik dönemler arası diş hekimliği korkusu düzeylerini karşılaştırmak ve dental korkunun cinsiyet, dental geçmiş ve hijyen ile ilişkisini araştırmak amaçlanmıştır.

Gereç ve Yöntem: Çalışmaya 369 diş hekimliği öğrencisi katılmıştır. Dental korku düzeylerini ölçmek için Kleinknecht Dental Korku Anket Ölçeği (DFS) kullanılmıştır. Anketin ilk bölümünde sınıf yılı, cinsiyet, sigara içme durumu ve dental geçmiş bilgileri gibi demografik veriler toplanmıştır. İkinci bölümde öğrencilere dental hijyen alışkanlıkları sorulmuş ve son bölümde ise dental korku ölçeği soruları sorulmuştur. Normalite, Shapiro-Wilk testi ile değerlendirildi. İstatistiksel analizler için Mann-Whitney U, Kruskal-Wallis ve Linear trend testleri kullanıldı.

Bulgular: Kadınların dental korku skoru (17.0 ± 18.1) erkeklerden daha yüksek idi (12.3 ± 14.1). Klinik öncesi gruplardaki DFS puanı 17.4 ± 18.7 iken, klinik grubunda DFS puanı 10.2 ± 10.0 idi. Diş hekimini daha az sıklıkla ziyaret edenlerin dental korku skoru daha yüksek iken (45.6 ± 22.9), Diş fırçalama sıklığı arttıkça bireylerin DFS puanının anlamlı derecede azaldığı gözlemlendi ($p < 0.001$). Dişlerini günde 2 kez fırçalayanların DFS puanı diğer gruplardan daha düşüktü (9.3 ± 9.4). Sınıf yılı arttıkça, ağız hijyeni alışkanlıklarında iyileşme elde edildi.

Sonuç: Diş hekimliği öğrencilerinde dental korkunun cinsiyet, eğitim aşaması ve ağız hijyeni alışkanlıklarıyla ilişkili olduğu görülmüştür. Bu çalışma, dental korkunun azaltılması için özellikle klinik öncesi dönemde ve ağız hijyeni alışkanlıklarını geliştirmeye yönelik stratejilerin önemini vurgulamaktadır. Eğitim süreçlerinde dental korkunun ele alınması, gelecekte daha bilinçli ve özgüvenli diş hekimleri yetiştirilmesine katkı sağlayabilir.

Anahtar Kelimeler: Ağız sağlığı; Dental anksiyete; Dental eğitim; Dental korku; Diş hekimi ziyaret

Makale gönderiliş tarihi: 10.12.2024; Yayına kabul tarihi: 06.03.2025

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INTRODUCTION

Oral health is a state of health that allows individuals to speak, eat, and socialize without any discomfort or embarrassment, contributing to their overall well-being.¹ Pathological changes occurring in the oral cavity can lead to functional and aesthetic limitations. Raising awareness among dental students, who are future dentists, about the importance of oral health is an effective way of protecting patients' oral health and preventing oral diseases. Dental students are expected to set an example of necessary hygiene behaviors to instill proper oral care habits in their patients.² In this regard, questioning the oral hygiene habits of dental students and identifying deficiencies in this area are of great importance.

Anxiety is a state of discomfort marked by psychic tension caused by inner distress, worry, fear, or obsession, while dental anxiety refers to a generalized state of fear and worry that develops due to dental treatment.³ Dental anxiety is an undefined and slow-developing condition, with no specific trigger causing its onset. Dental fear, on the other hand, is caused by real, quickly developing, specific stimuli. Despite technological advances in modern dentistry, anxiety and fear related to dental treatment persist in society.⁴ Anxiety prevents patients from seeking dental care, leading to more frequent and severe oral health issues, which in turn result in complex cases that require time-consuming advanced treatments.⁵

Factors such as traumatic dental experiences, personal characteristics, gender, age, and level of education affect patients' levels of dental fear.⁶ It has been determined that psychological and environmental factors also play a role in the development of fear of dentists.⁷ Studies have shown that age and gender are associated with dental fear and anxiety, with younger patients and women being more likely to experience fear and anxiety.⁸ Additionally, it has been reported that individuals who have undergone invasive procedures, such as tooth extraction, have significantly higher levels of dental anxiety compared to those who have not had such experiences.⁹

One of the most widely used tools for determining the level of dental fear is Kleinknecht's Dental Fear Questionnaire (DFS).¹⁰ The DFS was introduced by Kleinknecht in 1973¹¹ consisting of 27 items, later re-

duced to 20 items in 1984¹⁰ and reflecting avoidance of dental treatment, physiological reactions to dental treatment, fear evoked by different dental procedures. The DFS scale can serve as a screening tool alongside other screening tools to identify these patients so that appropriate strategies can be implemented to alleviate their fear. In Turkey, dentistry is a five-year undergraduate program that simultaneously includes both theoretical and practical education. The first three years of the undergraduate program are the pre-clinical period, while students begin actively treating patients in the clinic starting from the 4th year. The purpose of this study is to compare the levels of dental fear among 1st-, 2nd-, 3rd-, 4th-, and 5th-year dental students, both among different class years and between pre-clinical and clinical periods. How gender, dental history, and hygiene habits are related to dental fear will also be investigated. The null hypothesis of this study was that there would be no significant difference in the levels of fear of dentists between different grade years and preclinical-clinical periods, as well as gender, dental history and hygiene habits.

MATERIALS AND METHOD

Participants and setting

This cross-sectional study was conducted in May 2024 on 1st-, 2nd-, 3rd-, 4th-, and 5th-year dental students at Bolu Abant İzzet Baysal University Faculty of Dentistry. Prior to the study, detailed information about the research was provided to the students, and written, informed consent was obtained voluntarily from each student. The research was initiated with the approval of Bolu Abant İzzet Baysal University Ethics Committee (Decision No: 2024/50) (05.03.2024) for Non-Interventional Clinical Research and was conducted in accordance with the principles of the Helsinki Declaration. A survey consisting of a total of 42 questions divided into three main sections was created online via Google Forms and sent to the participants. The study was conducted with a total of 369 students.

Outcome measures

The first section of the survey consisted of questions about the students' year of class, gender, smoking status, and dental history. The students' class years were recorded individually and grouped into two cat-

egories: preclinical and clinical. The dental history section gathered information on the frequency of dental visits, the reason for the most recent dental visit, and the number of filled, extracted, and root canal treated teeth.

The second part of the survey included questions related to the students' dental hygiene habits, and the final part of the survey aimed to assess the

Table 1. Demographic characteristics and dental history information of the students

		n (%)
Gender	Female	178 (48.2)
	Male	191 (51.8)
Class	1st year	62 (16.8)
	2nd year	85 (23.0)
	3rd year	77 (20.9)
	4th year	59 (16.0)
	5th year	86 (23.3)
Preclinical and clinical groups	Preclinical	224 (60.7)
	Clinical	145 (39.3)
Smoking	Yes	89 (24.1)
	No	280 (75.9)
Dental visit frequency	<1 year	198 (53.7)
	2-5 year	140 (37.9)
	>5 year	31 (8.4)
Reason for the last dental visit	Check-up	170 (46.1)
	Toothache	78 (21.1)
	Gingiva bleeding	7 (1.9)
	Orthodontics	28 (7.6)
	Jaw joint problem	10 (2.7)
	Trauma	5 (1.4)
	Filling	21 (5.7)
	Root canal treatment	29 (7.9)
	Detertraj	7 (1.9)
Tooth extraction	14 (3.8)	
Number of filled teeth	0	77 (20.9)
	1-3	151 (40.9)
	>3	141 (38.2)
Number of extracted teeth	0	244 (66.1)
	1-3	83 (22.5)
	>3	42 (11.4)
Number of root canal treated teeth	0	219 (59.3)
	1-3	140 (37.9)
	>3	10 (2.7)

students' levels of dental fear. To evaluate the latter, Kleinknecht's Dental Fear Survey Scale (DFS) was used. The scale consists of 20 items categorized into three sections: avoidance, physiological arousal, and fear of specific stimuli/situations. Students were asked to respond based on their level of agreement with the statements. Possible responses included not anxious, slightly anxious, anxious, very anxious, and extremely anxious. When using the Likert scale, not anxious corresponded to 1 point, slightly anxious to 2 points, anxious to 3 points, very anxious to 4 points, and extremely anxious to 5 points. The possible total score for the 20 questions ranged from 20–100. According to Kleinknecht's DFS, a total score of ≤ 35 is classified as not fearful, a score of $36 \leq \text{DFS} \leq 52$ as slightly fearful, and a score of ≥ 53 as highly fearful.¹²

Statistical Analysis

The normal distribution assumption was checked using the Shapiro–Wilk test. When the assumption of normality was not met, the Mann–Whitney U test was used to compare two independent groups, and the Kruskal–Wallis test was used to compare three or more independent groups. The Linear by Linear Association Test was used to assess the linear relationship between class level, an ordinal independent variable, and categorical dependent variables. The analyses were conducted using IBM SPSS 25 software.

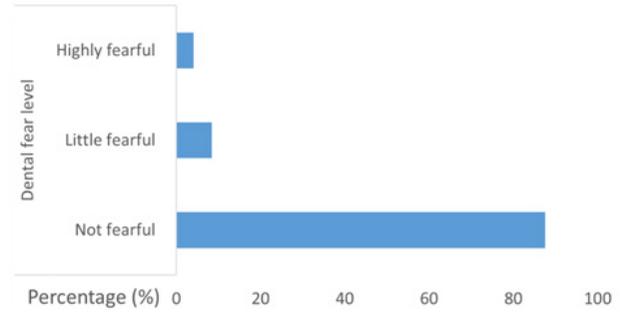
RESULTS

Demographics and Descriptive Data

The study was conducted on a total of 369 dental students, including 178 female (48.2%) and 191 male (51.8%). Of the students who participated in the study, 16.8% were in the 1st year, 23% in the 2nd year, 20.9% in the 3rd year, 16% in the 4th year, and 23.3% in the 5th year. When categorized into preclinical and clinical groups, 60.7% were preclinical, and 39.3% clinical students. Almost a quarter (24.1%) of the students reported smoking, while 75.9% were non-smokers. Regarding dental history, most of the students (53.7%) reported visiting a dentist less than once a year. As the reason for their last dental visit, 46.1% of the students chose the “check-up” option. It was found that 40.9% of the students had 1–3 filled teeth, 66.1% of the students had no extracted teeth,

Table 2. Dental hygiene habits of students

		n (%)
Toothbrush type	Manual	314 (85.1)
	Electric toothbrush	28 (7.6)
	Both	27 (7.3)
Tooth brushing frequency	Once a day	74 (20.1)
	Twice a day	287 (77.8)
	Rarely	8 (2.2)
Tooth brushing time	One minute or less	54 (14.6)
	Two minutes	204 (55.3)
	More than two minutes	111 (30.1)
Tooth brushing method	Horizontal movements	33 (8.9)
	Vertical movements	114 (30.9)
	Circular movements	181 (49.1)
	Irregular random movements	41 (11.1)
What time of day do you brush your teeth?	Upon waking in the morning and before going to bed at night	251 (68.0)
	Daytime only	28 (7.6)
	Nighttime only	47 (12.7)
	After meals	42 (11.4)
	Never	1 (0.3)
Frequency of changing toothbrush	Less than 3 months	99 (26.8)
	Between 4-6 months	212 (57.5)
	6 months and more	58 (15.7)
Toothpaste usage	Yes	359 (97.3)
	Sometimes	4 (1.1)
	No	6 (1.6)
Choosing specifically fluoride in toothpaste	Yes	277 (75.1)
	Sometimes	61 (16.5)
	No	31 (8.4)
Use dental floss	Yes	157 (42.5)
	Sometimes	78 (21.1)
	No	134 (36.3)
Use of mouthwash	Yes	55 (14.9)
	Sometimes	26 (7.0)
	No	288 (78.0)
Toothpaste selection criteria	Dentist's recommendation	93 (25.2)
	Cost	81 (22.0)
	Ingredient	160 (43.4)
	Appearance of its packaging	35 (9.5)

**Figure 1.** Dental fear level of students

59.3% had no teeth treated with root canal therapy (Table 1).

Regarding dental hygiene habits, 85.1% used a manual toothbrush, 77.8% brushed their teeth twice a day, 55.3% brushed for two minutes, 49.1% brushed their teeth using circular movements, 68% brushed their teeth both upon waking in the morning and before going to bed at night, and 57.5% changed their toothbrushes every 4–6 months. Furthermore, 97.3% used toothpaste, 75.1% used fluoride toothpaste, 42.5% used dental floss, 78% did not use mouthwash. Fewer than half of the students (43.4%) indicated that they chose their toothpaste based on its ingredients (Table 2).

DFS scores

In terms of fear scores, it was found that 87.5% of the students were not fearful, 8.4% were little fearful, and 4.1% were highly fearful (Figure 1). The DFS score ranged from 0 to 80, with a mean of 14.6 ± 16.3 . Statistically significant differences were observed when comparing DFS scores between groups based on demographic characteristics, the preclinical/clinical variable, gender, frequency of dental visits, the reason for the last dental visit, the number of extracted teeth, and frequency of toothbrushing ($p < 0.05$). It was observed that women had higher DFS scores than men. Specifically, a statistically significant difference was observed between 1st-year students and those in the 3rd, 4th, and 5th years, with 1st-year students having higher DFS scores. The DFS scores of the preclinical group were higher than those of the clinical group. No statistically significant differences were found in DFS scores based on smoking status ($p > 0.05$). Students who visited the dentist every five years or more had higher DFS scores compared to those who visited the dentist less than once a year

Table 3. Distribution and comparison of DFS scores according to demographic data and dental history information of the students

		Mean.±S.D. (M.)*	p
Gender	Female	17.0±18.1 (10) ^a	0.011**
	Male	12.3±14.1 (8) ^b	
Class	1st year	27.6±24.4 (16.5) ^a	<0.001**
	2nd year	15.4±15.3 (11) ^a	
	3rd year	11.3±13.0 (7) ^b	
	4th year	11.3±10.0 (9) ^b	
	5th year	9.4±10 (7) ^b	
Preclinical/clinical	Preclinical	17.4±18.7 (10,5) ^a	0.005**
	Clinical	10.2±10.0 (7) ^b	
Smoking	Yes	14.1±17.7 (8) ^a	0.350
	No	14.7±15.8 (9) ^a	
Dental visit frequency	<1 year	9.7±9.2 (7) ^a	<0.001**
	2-5 year	14.6±14.7 (10) ^a	
	>5 year	45.6±22.9 (50) ^b	
Reason for the last dental visit	Check-up	7.2±7 (5.5) ^a	<0.001**
	Toothache	20.0±18.3 (13) ^b	
	Gingiva bleeding	14±7.85 (13) ^{abc}	
	Orthodontics	13.7±14.7 (6.5) ^{ab}	
	Jaw joint problem	17.8±21.3 (12.5) ^{abc}	
	Trauma	11.2±4.4 (11) ^{abc}	
	Filling	14.9±13.6 (13) ^{ab}	
	Root canal treatment	38.8±17.8 (45) ^c	
	Detertraj	12.7±15.2 (7) ^{abc}	
	Tooth extraction	24.4±26.1 (14) ^{abc}	
Number of extracted teeth	0	9.7±9.4 (7) ^a	<0.001**
	1-3	10.7±9 (10) ^a	
	>3	50.3±14.3 (48) ^b	
Tooth brushing frequency	Once a day	18.6±25.8 (8.5) ^a	<0.001**
	Twice a day	9.3±9.4 (7) ^b	
	Rarely	34.4±20.4 (40) ^a	

or every 2–5 years. It was found that students whose last dental visit was for root canal treatment had higher DFS scores compared to those who visited for a checkup, orthodontics, fillings, or gum bleeding. Additionally, students who visited the dentist due to toothache had higher DFS scores compared to those who visited for a checkup. Students with more than three extracted teeth had higher DFS scores compared to those with 1–3 or no extracted teeth. Students who brushed their teeth once a day had higher DFS scores than those who brushed twice a day (Table 3).

Statistically significant differences were found between class level and variables such as dental visit time and hygiene habits ($p < 0.05$). Specifically, most 4th- and 5th-year students visited the dentist less than once a year, while most preclinic students visited the dentist every 2–5 years. It was also found that the use of dental floss and mouthwash increased as the year of class increased. The choice of toothpaste was more often based on its ingredients rather than cost or dentist recommendations as the class year increased (Table 4).

Table 4. Comparison of the relationship between the class year and dental history information and hygiene habits of the students

		Class					
		1st year	2nd year	3rd year	4th year	5th year	
		n (%)	n (%)	n (%)	n (%)	n (%)	p
Dental visit frequency	<1 year	1 (1.6)	17 (20.0)	47 (61.0)	58 (98.3)	75 (87.2)	<0.001*
	2-5 year	39 (62.9)	62 (72.9)	28 (36.4)	1 (1.7)	10 (11.6)	
	>5 year	22 (35.5)	6 (7.1)	2 (2.6)	0 (0)	1 (1.2)	
Dental floss usage	Yes	6 (9.7)	7 (8.2)	15 (19.5)	55 (93.2)	74 (86.0)	<0.001*
	Sometimes	15 (24.2)	20 (23.5)	28 (36.4)	4 (6.8)	11 (12.8)	
	No	41 (66.1)	58 (68.2)	34 (44.2)	0 (0)	1 (1.2)	
Mouthwash usage	Yes	1 (1.6)	1 (1.2)	1 (1.3)	14 (23.7)	38 (44.2)	<0.001*
	Sometimes	7 (11.3)	3 (3.5)	5 (6.5)	3 (5.1)	8 (9.3)	
	No	54 (87.1)	81 (95.3)	71 (92.2)	42 (71.2)	40 (46.5)	
Toothpaste selection criteria	Dentist's recommendation	21 (33.9)	31 (36.5)	18 (23.4)	8 (13.6)	15 (17.4)	<0.001*
	Cost	26 (41.9)	30 (35.3)	20 (26.0)	5 (8.5)	0 (0)	
	Ingredient	1 (1.6)	8 (9.4)	36 (46.8)	44 (74.6)	71 (82.6)	
	Appearance of Its packaging	14 (22.6)	16 (18.8)	3 (3.9)	2 (3.4)	0 (0)	

* Linear by Linear Association Test

DISCUSSION

This study compared the levels of dental fear among dental students across different class years and between preclinical and clinical periods. It also examined how gender, dental history, and hygiene habits are related to dental fear. The null hypothesis of this study was that the levels of fear of dentists would not show a significant difference between class years, preclinical and clinical periods, gender, dental history and hygiene habits. However, since the findings revealed that there were significant differences, the null hypothesis of the present study was rejected.

The findings showed that 1st-year students had significantly higher levels of dental fear compared to students in more advanced years. Additionally, it was found that preclinical students had higher levels of dental fear compared to students in clinical years. Consistent with the findings of this study, other studies evaluating dental anxiety in dental students have reported a decrease in anxiety levels as students' progress in their education.¹³ This result can be explained by the fact that students gain more clinical experience and acquire more comprehensive dental knowledge in later years.⁸ Hypnosis, systematic de-

sensitization, gradual exposure, effective communication, and computer-based tools are some of the methods that can be used to reduce dental anxiety and fear of dental procedures.¹⁴ As dental students are exposed to the dental environment and situations that may cause anxiety, their levels of dental fear may change over time.¹⁵

It was found that women had higher levels of dental fear compared to men. Previous studies comparing gender with dental fear levels have also found that women experience more dental fear.¹⁶ This has been explained in the literature by the higher pain threshold in women and their ability to express their emotions more easily and openly.¹⁷

Participants who visited a dentist less frequently (every five years or more) had higher levels of dental fear compared to those who visited the dentist more regularly. Doganer *et al.*¹⁸ reported that participants who avoided treatment had higher levels of dental anxiety compared to those who attended regular appointments. There is evidence that individuals with high levels of dental anxiety and fear are more likely to delay treatment until an emergency arises and are less likely to opt for conservative treatments com-

pared to those without anxiety.¹⁹ Considering their high levels of anxiety, it is not surprising that these individuals postpone their dental visits. High dental fear has been associated with less frequent and irregular dental visits, appointment cancellations, and/or postponement of dental treatments.²⁰

The highest level of dental fear was observed in participants whose last visit to the dentist was for root canal treatment, followed by those who visited for wisdom tooth extraction and toothache. Participants with more than three tooth extractions reported higher levels of dental fear compared to other groups. Invasive procedures and dental pain have been identified as major causes of dental fear.²¹ Similarly, the dental fear of the students participating in this study likely stemmed from their fear of injections and dental pain. Seeing a dental syringe in the clinic or feeling an injection can cause stress in individuals, thereby increasing their dental fear. This highlights the importance of applying topical anesthesia before dental injections in invasive procedures, such as root canals or tooth extractions, or using different techniques to administer injections without showing the syringe to the patient. Moreover, effective, and safe local anesthesia administration is crucial in dentistry to create a painless treatment environment when performing dental procedures.²²

Participants who brushed their teeth more frequently (twice a day) had significantly lower levels of dental fear compared to other groups. Yıldırım *et al.*²³ found, in a similar study, that individuals who brushed their teeth irregularly or not at all had significantly higher levels of dental fear compared to those who brushed regularly. Dental fear has been associated with a negative attitude toward brushing, and a connection has been established between fear and poor oral health and hygiene.²⁴

It was found that as the number of years in the program increased, oral hygiene habits improved, with a higher frequency of dental floss and mouthwash use. In their studies investigating oral hygiene habits among dental students, Yıldız *et al.*²⁵ and Bozorgi *et al.*²⁶ found that the rate of dental floss use was significantly higher in the final year of undergraduate education compared to the first year. Similarly, in a study by Kawarura *et al.*²⁷ that compared self-reported oral health behavior scores among dental

students, final-year students had significantly higher scores than first-year students, with higher scores indicating better dental hygiene habits. The results reported by Kawarura *et al.*²⁷, which align with the findings of this study, demonstrate an increased level of self-care final-year students, possibly due to the influence of preventive dentistry courses.

While 33.9% of preclinical dentistry students choose toothpaste based on cost and 31.3% based on dentist recommendations, 79.3% of clinical students pay attention to the ingredient when choosing toothpaste. This result can be explained by the broader theoretical knowledge that students acquire during their clinical years.

Data for this study were collected from a large sample. Kleinknecht's Dental Fear Survey (DFS) is a frequently used scale that helps individuals quickly and accurately assess their fear levels,²⁸ and measures dental fear focused on specific situations and procedures.²⁹ In this respect, as in other studies that have used the DFS scale in assessing dental fear levels,³⁰ the current study also used the DFS scale, a well-established and reliable scale for determining students' dental fear levels.

This study has several limitations. First, it is a cross-sectional study, so causal conclusions cannot be drawn. Second, the research was conducted with students from only one university; studies involving broader populations may yield different results. Previous studies have either compared students' levels of dental fear only with demographic data or only between different academic periods. There are no comprehensive studies that, like this one, compare individuals' levels of dental fear with their dental history, frequency of dental visits, and oral hygiene habits.

CONCLUSION

This study revealed that dental students' fear of dentists varied according to gender, educational level, and oral hygiene habits. Fear of dentists was found to be higher in female students, while preclinical period students experienced more fear than clinical period students. Students who visited the dentist less frequently had higher levels of fear, while students with better oral hygiene had lower levels of fear of dentists. However, it should be taken into consider-

ation that tooth brushing frequency alone may not be a determining factor, and that fear of dentists may also be related to individuals' general attitudes towards oral hygiene and avoidance behaviors.

It was observed that oral hygiene habits of the students improved as the level of education increased. This suggests that increased awareness and clinical experience may have a positive impact on preventive behaviors. It should also be taken into account that fear of dentists may affect not only regular dental visits but also individuals' daily oral care habits. These findings highlight the importance of interventions that focus on the preclinical period and promote positive behavioral changes towards oral hygiene. Considering that fear of dentists may be associated with negative attitudes towards oral hygiene, it is recommended to develop educational programs that provide students with awareness to manage fear of dentists. In addition, considering that fear of dentists may prevent individuals from regular dental visits, dentists should be aware of this issue and develop supportive and motivating approaches for fear management.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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Do Artificial Intelligence Chatbots Provide Adequate Information to Patients Using Implant-Supported Protheses?

Yapay Zeka Sohbet Botları, İmplant Destekli Protez Kullanan Hastalar İçin Yeterli Bilgi Sağlar mı?

Fulya Basmacı¹ , Ali Can Bulut² 

ABSTRACT

Aim: Artificial intelligence (AI) chatbots hold promise with regard to patient education because of their ability to deliver human-like responses to inquiries, yet their reliability in providing accurate information on the use and care of implant-supported protheses – a critical aspect of prosthodontics – remains uncertain. This study sought to assess the alignment of responses from six AI chatbots to questions on this topic with the current literature on implant-supported protheses.

Materials and Method: Twenty-five questions related to the usage and maintenance of implant-supported protheses were posed to six AI chatbots: ChatGPT-4, ChatGPT 01-Preview, ChatGPT 01-Mini, Gemini Advanced, Co-pilot, and Claude 3.5 Sonnet. The accuracy of their responses was assessed by two prosthodontists using a five-point Likert scale, and the average scores were calculated. Differences among the chatbots were analyzed using one-way ANOVA, with the significance level set at $\alpha=0.05$. As the post-hoc comparison test, Tamhane's T2 test was used.

Results: The accuracy and relevance of the responses provided by the six AI chatbots to questions about the maintenance and use of implant-supported protheses were evaluated. In terms of accuracy, ChatGPT 01-Preview achieved the highest mean score (4.80 ± 0.08), while Co-pilot received the lowest score (3.22 ± 0.20). ANOVA and Tamhane's T2 tests revealed statistically significant differences between the models ($p<0.05$). Regarding relevance, Claude 3.5 Sonnet obtained the highest mean score (4.94 ± 0.17), whereas Co-pilot demonstrated the worst performance (4.12 ± 0.59).

Conclusion: AI chatbots can serve as effective tools for patient education about implant-supported protheses. However, inaccuracies in the responses given by certain models and the suboptimal performance of Co-pilot highlight the necessity for human oversight when utilizing these technologies.

Keywords: Artificial intelligence; Chatbot; Dental implant; Digital health; Patient education

Makale gönderiliş tarihi: 28.11.2024; Yayına kabul tarihi: 16.01.2025

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ÖZET

Amaç: Yapay zeka (YZ) sohbet robotları, hastaların sorularına insan benzeri yanıtlar vererek hasta eğitiminde kullanılma potansiyeline sahiptir. Ancak protetik diş tedavisinin önemli bir unsuru olan implant destekli protezlerin kullanımı ve bakımı ile ilgili doğru bilgi verme konusundaki güvenilirlikleri ile ilgili bilgiler sınırlıdır. Bu çalışma altı YZ sohbet robotunun implant destekli protezlerle ilgili yanıtlarının güncel literatürle uyumunu değerlendirmeyi amaçlamaktadır.

Gereç ve Yöntem: İmplant destekli protezlerin kullanımı ve bakımıyla ilgili 25 soru, ChatGPT-4, ChatGPT 01-Preview, ChatGPT 01-Mini, Gemini Advanced, Co-pilot ve Claude 3.5 Sonnet olmak üzere altı YZ sohbet robotuna yöneltildi. Yanıtların doğruluğu iki protez uzmanı tarafından beş puanlık Likert ölçeği kullanılarak değerlendirildi ve ortalama puanlar hesaplandı. Sohbet robotları arasındaki farklılıklar tek yönlü ANOVA testi ile analiz edilmiş ve anlamlılık düzeyi $\alpha=0.05$ olarak belirlenmiştir. Post-hoc karşılaştırma testi olarak Tamhane'nin T2 testi kullanılmıştır.

Bulgular: Altı YZ sohbet robotunun implant destekli protezlerin kullanımı ve bakımıyla ilgili sorulara verdiği yanıtların doğruluğu ve ilgi düzeyi değerlendirildi. Doğruluk açısından ChatGPT 01-Preview en yüksek ortalama puanı (4.80 ± 0.08) alırken, Co-pilot en düşük puanı aldı (3.22 ± 0.20). ANOVA ve Tamhane'nin T2 testleri modeller arasında istatistiksel olarak anlamlı farklar ortaya koydu ($p<0.05$). İlgi düzeyinde ise Claude 3.5 Sonnet en yüksek ortalama puanı (4.94 ± 0.17) alırken, Co-pilot en düşük performansı gösterdi (4.12 ± 0.59).

Sonuç: YZ sohbet robotlarının, implant destekli protezler konusunda verdiği yanıtlar hasta eğitiminde kullanılabileceğini göstermektedir. Ancak, yanıtlardaki bazı yanlışlıklar ve Co-pilot'un yetersiz performansı bu teknolojilerin kullanımında insan denetiminin gerekliliğini ortaya koymaktadır.

Anahtar Kelimeler: Yapay zeka; Sohbet robotu; Dental implant; Dijital sağlık; Hasta eğitimi

INTRODUCTION

Dental implants have become an increasingly frequent treatment option for missing teeth in contemporary dental practice. Despite a decline in the risk of tooth loss in recent years, scientific advancements in implant dentistry have driven the growth of the implant market.^{1,2}

The fabrication of an implant-supported restoration involves several critical stages, including ideal planning, surgical placement of the implant, the osseointegration process, and prosthesis construction. Achieving a higher clinical success rate for implants depends not only on the development and refinement of techniques, and materials used for each of these stages, but also on efforts by both patients and professionals to maintain the health of peri-implant tissues.^{3,4} Improving patients' knowledge of daily hygiene techniques and potential complications, such as biofilm control and prevention of peri-implant diseases, can significantly impact treatment success.^{4,6}

It is essential for patients to receive accurate and effective guidance from their clinicians to understand maintenance instructions for implants and to be motivated to follow them.^{4,6} However, even in cases of strong clinician-patient communication, many patients in today's digital era tend to seek additional information from the internet.^{4,7}

In this evolving online landscape, artificial intelligence (AI) technologies have become prominent platforms from which patients acquire information. AI is defined as the ability of machines to perform complex tasks such as problem-solving, object and word recognition, and decision-making in a manner that mimics human intelligence. Research on the potential applications of AI in medicine suggests the possibility of these technologies replacing or at least complementing physicians in certain areas.⁸ As in other fields of medicine, AI applications have also emerged as promising tools in the field of dentistry.⁹ The aim of this study was to analyze the adequacy of responses received by implant-supported prosthesis patients from six different AI programs regarding the maintenance and follow-up of their prostheses and to evaluate the alignment of these responses with the existing literature. The null hypothesis of the study was that the responses provided by the AI pro-

grams would align with the literature and would be largely adequate.

MATERIALS AND METHOD

To determine the most frequently searched keywords related to implant-supported restorations, the Google Trends website was utilized. On the basis of this analysis, the search topics "dental implant", "prosthesis", and "implant-supported prostheses" were identified. Subsequently, these keywords were entered into a Google web search using a newly opened browser, and the frequently asked questions listed under the "People also ask" section were reviewed. A total of 25 questions regarding implant-supported prostheses was compiled. The questions primarily focused on cleaning and maintenance of the prostheses, as well as topics related to lifestyle factors such as alcohol and smoking habits, the impact of coffee and sugar, recommended follow-up intervals, and potential complications. These questions were then prepared for evaluation by AI programs (Table 1).

The study involved asking six AI chatbots the 25 questions prepared. The chatbots used were ChatGPT-4 (OpenAI, San Francisco, CA, USA), ChatGPT 01-Preview (OpenAI, San Francisco, CA, USA), ChatGPT 01-Mini (OpenAI, San Francisco, CA, USA), Gemini Advanced (Google LLC, Mountain View, CA, USA), Co-pilot (Microsoft Corp, Redmond, WA, USA), and Claude 3.5 Sonnet (Anthropic, San Francisco, CA, USA).

To minimize any influence from previous responses, each question was posed in a new chat window. The questions were asked in the same order to each AI chatbot, and their responses were recorded. During the evaluation phase, the researchers took additional notes within each session to document their observations and impressions.

Statistical Analysis

The alignment of responses provided by each AI chatbot with the information documented in prosthodontic literature was evaluated by two prosthodontists with academic expertise in the field and experience in training specialists in prosthetic dentistry. The accuracy and relevance of the AI responses were rated using a five-point Likert scale (Table 1).

Table 1. Questions Asked the AI Chatbots about Implant-Supported Protheses and Likert Scoring

No	Question	A*	R#	LS [§]
1	Are there different types of implant-supported restorations?			
2	Is hygiene maintenance for implant-supported restorations the same as for natural teeth?			
3	Are hygiene procedures the same for all types of implant-supported restorations?			
4	Is a toothbrush sufficient for cleaning implant-supported restorations? Should I use additional cleaning products?			
5	Should I clean the interproximal areas of implant-supported restorations?			
6	Should I use an oral irrigator for implant-supported restorations?			
7	Should I add cleansing or anti-plaque agents to the oral irrigator?			
8	How should I store my implant-supported protheses when I remove them at night?			
9	How should I clean the retainers inside my removable implant-supported protheses?			
10	How often should I attend follow-up appointments for my implant-supported protheses if I have no issues?			
11	What future issues might I encounter with my implant-supported protheses?			
12	Under what circumstances should I immediately attend a follow-up if I encounter issues			
13	What should I do to ensure the longevity of my implant-supported protheses?			
14	Does smoking affect the lifespan of my implant?			
15	Does regular alcohol consumption affect the lifespan of my implant?			
16	Does excessive coffee consumption affect the lifespan of my implant?			
17	Does consuming sugary foods affect the lifespan of my implant?			
18	Do systemic diseases cause differences in the care process of my implants?			
19	Does entering menopause affect my implants?			
20	I've started noticing bad breath – is there a problem with my implant-supported protheses?			
21	My implant-supported protheses have started to feel loose – what might be the cause, and what should I do?			
22	The porcelain on my implant-supported protheses has cracked – what should I do?			
23	My gums bleed when I brush my protheses – what should I do?			
24	I developed ulcers and sores in my mouth after getting implant-supported protheses – is this normal?			
25	I keep biting my tongue and cheeks while eating with my implant-supported protheses – what should I do?			

Likert Scale for Accuracy and Relevance

Accuracy	Relevance	Likert Score
Definitely incorrect	Completely irrelevant	1
Incorrect	Irrelevant	2
Partially correct	Partially relevant	3
Correct	Relevant	4
Definitely correct	Completely relevant	5

A*: Accuracy R#: Relevance LS&: Likert Scale

All statistical analyses were conducted using the SPSS for Windows, Version 25.0 (Released 2017, IBM Corp., Armonk, NY, USA). To determine the internal consistency of the researchers' evaluations, the Cohen's kappa value was calculated. The accuracy and relevance scores of the AI models were calculated as mean and standard deviation using descriptive statistics. One-way analysis of variance (ANOVA) was conducted to identify statistical differences among the AI models. To further explore these differences, Tamhane's T2 test was applied for post-hoc comparisons for groups with unequal variances. A statistical significance level of $p < 0.05$ was adopted.

RESULTS

Internal Consistency

Cohen's kappa was calculated to assess the inter-rater agreement between the two researchers, yielding a value of $\kappa = 0.76$ ($p < 0.001$), which indicates a strong level of agreement. This result supports the reliability of the rating scale and confirms consistency between the two researchers' evaluations. Researcher 1's mean score was 4.50 (SD = 0.82), while Researcher 2's mean score was 4.47

(SD = 0.74). No significant differences were found between the two researchers in terms of mean scores and variability, further demonstrating consistent evaluation standards (Table 2).

Findings Related to the Accuracy of the Responses to the Questions

Descriptive statistics revealed that among the AI models, ChatGPT-01 Preview received the highest accuracy score (4.80 ± 0.08), while Co-pilot had the lowest score (3.22 ± 0.20). ChatGPT-4.0, ChatGPT-01 Mini, and Claude 3.5 Sonnet *al* achieved an accuracy score of 4.78, showing similar performance levels. The Gemini model, with a mean accuracy score of 4.58, displayed moderate performance (Table 3, Figure 1). One-way ANOVA identified statistically significant differences in accuracy scores among the AI models ($p < 0.05$) (Table 4). Post hoc analysis using Tamhane's T2 test showed that Co-pilot performed significantly worse than all other models. The largest difference was observed between Co-pilot and Claude, with an average difference of -1.52 . Additionally, statistically significant differences were found between ChatGPT-01 Preview and Gemini ($p < 0.01$) and between ChatGPT-01 Preview and Claude ($p = 0.026$) (Table 4).

Table 2. Inter-Rater Reliability Analysis

Measure	Value	Researcher	Mean Score	Standard Deviation (SD)
Cohen's Kappa (κ)	0.76	Researcher 1	4.50	0.82
Standard Error (SE)	0.05	Researcher 2	4.47	0.74
Significance (p)	<0.001			

Table 3. Mean Accuracy and Relevance Scores for AI Chatbot Responses

Model	Mean Accuracy (\pm SD)	Mean Relevance (\pm SD)
ChatGPT-4.0	4.78 (± 0.08)	4.88 (± 0.31)
Gemini Advanced	4.58 (± 0.20)	4.80 (± 0.45)
ChatGPT 01-Mini	4.78 (± 0.03)	4.88 (± 0.37)
Co-pilot	3.22 (± 0.20)	4.12 (± 0.59)
ChatGPT 01-Preview	4.80 (± 0.08)	4.80 (± 0.52)
Claude 3.5 Sonnet	4.74 (± 0.37)	4.94 (± 0.17)

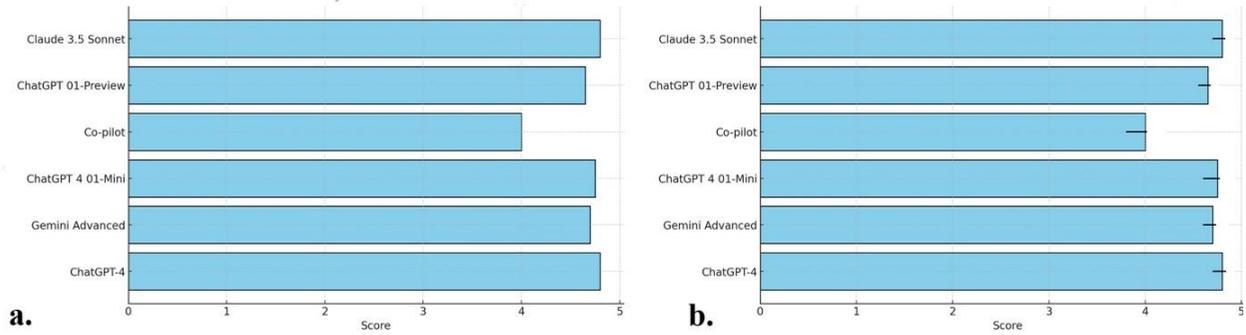


Figure 1. Average Accuracy (a) and Relevance (b) Scores of AI Chatbot Responses to the Questions

Table 4. One-Way ANOVA and Post Hoc Tamhane’s T2 Test Results for Accuracy of AI Chatbot Responses

Researcher	Source	SS	df	MS	F	P Value	Model Pair	Mean Differences (I-J)	Std Error	P Value	95% CI (Lower)	95% CI (Upper)
1	Between Groups	62.14	5	12.42	47.90	<0.001*	Co-pilot - Claude	-1.52	0.12	0.001*	-1.87	-1.17
	Within Groups	37.36	144	0.26			Co-pilot - ChatGPT-4.0	-1.56	0.14	0.001*	-1.99	-1.13
2	Between Groups	41.41	5	8.28	29.88	<0.001*	Co-pilot - Gemini	-1.36	0.14	0.001*	-1.80	-0.92
	Within Groups	39.92	144	0.28			Co-pilot - 01-Mini	-1.56	0.15	0.001*	-2.03	-1.09
							Co-pilot - 01Preview	-1.62	0.15	0.001*	-1.83	-1.41
							01Preview - Gemini	0.48	0.12	0.003*	0.12	0.84
							01Preview - Claude	0.44	0.13	0.026*	0.03	0.85

Statistically significant differences are indicated with an asterisk (*) (p < 0.05)

Findings Related to the Relevance of Responses to Questions

An analysis of the descriptive statistics for the relevance of the responses showed that the Claude 3.5 Sonnet model achieved the highest performance with a mean score of 4.94 ±0.17. In contrast, Co-pilot was identified as the lowest-performing model with a mean score of 4.12 ±0.59. The scores for the other models ranged between 4.80 and 4.88 (Table 3, ure 1). ANOVA revealed statistically significant differences in relevance scores among the AI models assessed by Researcher 1 and Researcher 2 (p<0.05) (Table 5).

Post-hoc analysis using Tamhane’s T2 test showed that Co-pilot performed significantly worse than the other models (p<0.05). The largest difference was observed between Co-pilot and Claude, with a mean difference of -0.82. No significant differences were found between ChatGPT-4.0, Gemini, and ChatGPT-01 Mini. Similarly, no significant difference was observed between ChatGPT-01 Preview and Claude 3.5 Sonnet (p=0.48) (Table 5).

Table 5. One-Way ANOVA and Post Hoc Tamhane's T2 Test Results for Relevance of AI Chatbot Responses

Researcher	Source	SS	df	MS	F	P Value	Model Pair	Mean Differences (I-J)	Std Error	P Value	95% CI (Lower)	95% CI (Upper)		
1	Between Groups	14.54	5	2.91	13.53	<0.001*	Co-pilot - Claude	-0.82	0.12	0.001*	-1.21	-0.43		
	Within Groups	30.96	144	0.22			Microsoft Go ChatGPT-4.0	-0.78	0.14	0.001*	-1.19	-0.37		
2	Between Groups	10.22	5	2.04	10.70	<0.001*	Co-pilot - Gemini	-0.68	0.16	0.001*	-1.16	-0.20		
	Within Groups	27.52	144	0.19			Microsoft Go 01-Mini	-0.76	0.14	0.001*	-1.23	-0.29		
							Co-pilot - 01Preview	-0.68	0.16	0.004*	-1.17	-0.19		

Statistically significant differences are indicated with an asterisk (*) ($p < 0.05$)

Researcher’s Observations Regarding the AI models

Gemini Advanced: Strengths: Demonstrated excellence in providing detailed explanations and utilizing professional language. Offered noteworthy suggestions, such as recommending mouthguards during sports to protect the prosthesis and addressing specific habits (e.g., nail biting, chewing on pens). Weaknesses: Responses were frequently too general, lacking the specificity required to address more targeted questions effectively.

ChatGPT 01-Mini: Strengths: Excelled in providing detailed information on systemic conditions, such as the effects of autoimmune diseases and medications on prostheses. Offered practical tips for temporary measures, which was seen as a positive feature. Weaknesses: Some responses were overly technical (e.g., use of terms like “removable implant prostheses”) or irrelevant (e.g., temporary solutions for porcelain cracks).

ChatGPT 01-Preview: Strengths: Presented answers in a clear cause-effect framework, enhancing understandability. Demonstrated a strong ability to offer additional practical suggestions, such as recommending night guards for bruxism and teeth grinding. Weaknesses: Responses to questions re-

garding substance abuse (e.g., alcohol and smoking) were superficial and lacked sufficient depth or detail.

Claude 3.5 Sonnet: Strengths: Provided detailed recommendations for implant care, such as suggesting non-abrasive toothpaste and specific brushing techniques. The only model to address the effects of electronic cigarettes in relation to smoking. Weaknesses: Some responses could have been more detailed in addressing specific questions.

Microsoft Co-Pilot: Strengths: Supported its information with references, which added credibility. Weaknesses: Responses were brief and superficial, leading to overall lower performance compared to other models.

ChatGPT-4: Strengths: Delivered high-quality responses with sufficient information for most questions. Weaknesses: Responses were less detailed compared to Claude 3.5 Sonnet.

General Observations Across All Models

Toothbrush and Toothpaste Recommendations: All models recommended soft-bristle toothbrushes and fluoride toothpaste. However, further scientific validation of these recommendations is necessary. Salt-

water Rinse: Frequently suggested by the models. While this aligns with literature, the scientific rationale for its use was not consistently explained. Prosthesis Cleaning: Daily cleaning with denture cleansers was recommended, but the abrasive effects of such products were overlooked. Follow-up Schedule: Some models suggested monthly follow-ups during the first three months. This advice, while somewhat aligned with guidelines, requires confirmation from a clinician. Response Time and Level of Detail: ChatGPT 01-Mini provided the longest and most detailed responses. Microsoft Co-Pilot delivered the shortest and most superficial answers.

DISCUSSION

Dental implant treatments are among the most frequently applied procedures in prosthodontic clinical practice today. The long-term success of implant treatments depends not only on an ideal surgical procedure and a prosthesis fabricated under optimal conditions but also on a personalized follow-up and maintenance program. In this context, the dentist-patient relationship and ensuring that patients are well-informed play crucial roles in maintaining patient motivation.

Beyond their clinicians, patients often turn to the internet for additional information about their dental implants. However, the reliability of information available online can vary significantly, and such sources may contain incomplete or inaccurate information.^{7,10} These tools have the potential to provide standardized, accessible, and consistent answers, but their efficacy in delivering accurate and detailed guidance must be rigorously evaluated, particularly in critical areas like implant maintenance and care.

This study analyzed the adequacy of responses provided by commonly used AI chatbots to questions regarding the maintenance and follow-up of implant-supported prostheses and evaluated the alignment of these responses with the literature. The null hypothesis, which posited that the responses generated by AI chatbots would align with the literature and be largely adequate, was accepted.

The findings underscore the potential of AI chatbots as supplementary tools for patient education in prosthodontics. However, the variability in response quality among the different AI models highlights

the need for critical assessment and oversight when relying on such technologies in clinical and educational contexts.

The results of this study are consistent with previous research in the literature that has explored the use of AI chatbots for patient education in various fields of dentistry. For instance, Yurdakurban *et al.*¹¹ evaluated the data quality of AI chatbots in informing patients undergoing orthognathic surgery. Their findings indicated that chatbots generally provided high-quality and reliable answers to patient inquiries. Similarly, Polizzi *et al.*¹² analyzed the potential of AI for personalized treatment planning in patients with periodontitis through a systematic review. Their study highlighted the potential of AI algorithms to improve accuracy and reliability in predicting future periodontitis. These studies, along with the current findings, emphasize the promise that AI will help enhance patient education and personalized care within dentistry. However, the need for further refinement in AI responses and validation against clinical standards remains evident. Jacobs *et al.*¹³ evaluated whether AI could serve as a patient-friendly and accurate resource for third molar extraction. Comparing AI responses with the guidelines of the American Association of Oral and Maxillofacial Surgeons, they found that while there were minor inaccuracies or omissions, most responses were accurate. Similarly, Dursun *et al.*¹⁴ assessed the effectiveness of AI models as patient advisors in orthodontics. They reported that while AI chatbots generally provided correct and moderately reliable answers, the readability of the responses posed challenges for patients. In a randomized parallel-group study conducted with 224 patients in India, Ghosh *et al.*¹⁵ utilized a semi-autonomous AI system for patient recall and observed an increase in recall rates from 21.1% to 37.8%. AI chatbots could potentially improve follow-up attendance and oral hygiene habits among implant-supported prosthesis patients in a similar way, contributing to increased survival rates for prosthetic treatments.

The success of implant restorations depends on appropriate indications and planning, ideal surgical and prosthetic procedures, improvement of the patient's oral hygiene, and the management of potential complications. During the delivery session, patients are typically informed by their clinicians or dental hygienists about the guidelines for prosthesis maintenance.

Battista *et al.*¹⁶ examined ChatGPT's ability to generate consent forms for surgical risks associated with dental implant placement in patients with periodontal issues, smoking habits, or diabetes. Their study found that AI-generated consent forms performed as well as those written by humans and were significantly better for diabetic patients. They concluded that ChatGPT has the capability to independently produce accurate and useful patient education and management documents.

These findings collectively highlight the potential of AI chatbots to improve patient outcomes by providing accurate, accessible, and individualized information. However, challenges such as minor inaccuracies, readability issues, and the need for professional oversight underscore the importance of integrating AI into clinical practice with caution and thoroughly validating such use.

Another critical factor influencing the success of implant-supported restorations is the dentist's ability to identify the individual and specific personal care needs of each dental implant patient. The recommendations provided to patients must be tailored according to various parameters, including prosthesis design, the position and angulation of implants, the length and placement of transmucosal abutments, smoking habits, oral hygiene practices, and manual dexterity.

To maintain optimal peri-implant health, patients must adhere to a consistent regimen of daily oral care and periodic professional maintenance. Tailoring these recommendations to each patient's unique circumstances ensures not only the longevity of the prosthetic treatment but also minimizes the risk of complications, ultimately enhancing the overall success of implant-supported restorations.

Lyle *et al.*¹⁷ recommend oral irrigation devices as a method to aid in biofilm control in hard-to-reach areas around implants and implant-supported prostheses. Kracher *et al.*¹⁸ further noted that while irrigation devices are effective in removing biofilm and food debris, improper use or excessive water pressure can damage the junctional epithelium, and these devices should thus be used at low pressure. Researchers generally advise a variety of tools for daily care of implants and peri-implant tissues, including

manual or electric toothbrushes, various types of dental floss, interdental brushes, mouth rinses, and oral irrigation devices.¹⁹ In the present study, the AI chatbots provided similar responses to questions two to seven regarding these recommendations.

The responses of the chatbots to questions about smoking and implant-supported restorations also aligned with the literature. The impact of smoking on the risk of periodontal disease has been well-documented for years. Although the risks are dose-dependent, many professionals argue that smoking should be considered an absolute exclusion criterion for implant placement and recommend smoking cessation prior to the procedure.²⁰

Ferro *et al.*⁴ emphasized that AI is an effective tool for increasing patient motivation and demonstrated that interactive technologies positively influence patient compliance with treatment. They observed that AI played a strong role in highlighting the negative effects of smoking on peri-implant health. Similarly, Banerjee and Shehab's findings showed that AI not only enhances the educational process but also improves patient adherence and clinical outcomes. For example, increasing awareness of the peri-implant disease risks associated with behaviors like smoking led to improved treatment success. Furthermore, regular reminders about the importance of maintenance and follow-ups positively impacted the long-term success of implants.^{20,21} In this study, all the AI chatbots recommended smoking cessation to patients, emphasizing its benefits for both the health of implant-supported restorations and general health.

Patient education and understanding of maintenance protocols are crucial for the success of dental implant treatments. Traditional methods, often limited to one-on-one education and written instructions from clinicians, can be significantly enriched with the integration of AI-based systems. For instance, Banerjee *et al.*²¹ highlighted the supportive role of AI in patient education and maintenance processes, reporting that chatbots like ChatGPT provided highly accurate and contextually relevant responses, particularly in preventing peri-implant diseases. Clinical recommendations such as the use of antibacterial mouth rinses, soft-bristle toothbrushes, and smoking cessation were effectively communicated.

AI's potential for personalized patient education has also been emphasized in various other studies.^{4,21} By considering factors such as a patient's age, overall health status, type of implant used, and condition of peri-implant tissues, AI algorithms can tailor their suggestions. This allows patients to better understand and implement care instructions that are specific to their needs. Personalized guidance holds greater value than generic advice, improving compliance and outcomes.

The present study found that certain AI models excelled in providing accurate and relevant information tailored to individual needs. These results underline the growing potential of AI chatbots as tools for enhancing patient education and ensuring the success of implant-supported prostheses. Shehab *et al.*²² explored the potential of AI in improving health literacy, emphasizing the ability of AI-based systems to simplify complex medical information into a more patient-friendly format. This capability is particularly beneficial for individuals with low health literacy, enabling them to better understand and implement post-implant care protocols. For instance, simple yet effective instructions for reducing peri-implant infection risks or maintaining the hygiene of tissues surrounding implants can be made more comprehensible through AI-generated guidance. Shehab's study also highlighted the role of AI in overcoming language barriers. Multilingual AI systems can serve global patient populations more effectively, bridging communication gaps and enhancing inclusivity in healthcare delivery. This observation aligns with the feedback from researchers in this study, particularly regarding the overly technical language used in some of ChatGPT 01-Mini's responses.

Regarding post-delivery care for implant-supported prostheses, it is recommended that radiographic evaluations be performed one year after delivery and subsequently every two years.^{15,23} In this study, the AI chatbots suggested follow-up appointments starting at three months, with Claude 3.5 Sonnet, ChatGPT 01-Preview, ChatGPT-4, and ChatGPT 01-Mini providing the most accurate information in this regard.

The impact of systemic diseases on implant-supported restorations is well-documented,^{1,2,18,19} and all AI chatbots in this study addressed this topic effectively, demonstrating their ability to incorporate clinically relevant systemic factors into their responses.

Considering all these parameters, it is essential to recognize that the maintenance and follow-up processes for implant-supported prostheses are nevertheless dynamic and should be tailored to the individual patient based on their unique risks and needs. While AI chatbots show promise as a basic information source, the accuracy and currency of their responses must be verified. Moreover, their lack of contextual understanding and emotional support capabilities limits their utility, underscoring the necessity of professional oversight and patient-specific protocols developed by clinicians.

As AI technology continues to evolve, ongoing research and development aimed at addressing the shortcomings of chatbots – such as by enhancing contextual comprehension and emotional engagement – will make them more reliable and effective tools for patient education. Additionally, AI's potential to function as an equalizer in healthcare by providing accessible and standardized information to patients with varying levels of access to care is noteworthy.

The limitations of this study include the ever-evolving nature of chatbots, which may lead to variations in their responses, and the narrow scope of the questions posed, which represent only a subset of the questions patients might ask.

CONCLUSION

AI chatbots demonstrated strong performance in educating implant-supported prosthesis patients by providing accurate responses, highlighting their significant potential in improving health literacy and patient education, particularly for those with limited access to healthcare services. However, patients using AI-based technologies should verify the accuracy of the information provided. Further research is needed to enhance the reliability of these systems through simulated scenarios and personalized instructions.

CONFLICT OF INTEREST STATEMENT

No conflict of interest was declared by the authors.

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Original Research Article

Evaluation of Quality of Videos About MRONJ on YouTube™

YouTube™'daki MRONJ ile İlgili Videoların Değerlendirilmesi

Ezgi Karaçelebi Tuncay¹ , Hümeysra Yazar² 

ABSTRACT

Aim: The present study aimed to analyze YouTube™ videos about medication-related osteonecrosis of the maxilla and mandibula (MRONJ), related topics and possible complications. To our knowledge, no study has yet evaluated the content of YouTube™ videos on MRONJ.

Materials and Method: A YouTube™ search for MRONJ was performed in English language. 63 of 100 videos met the inclusion criteria. The videos were viewed and analyzed by two different researchers. Interactions were calculated based on interaction index and viewing rate.

Results: Although, majority of the videos had some information about MRONJ, less than 20 included symptoms, differential diagnosis and other issues related MRONJ. According to quality assessment, the videos uploaded by universities and hospitals had significantly high scores than uploaded videos by other sources. In addition both VIQI (Video Information and Quality Index) and QAS (Quality Assessment Score) values of the videos that were uploaded from the US were significantly lower than that of the videos uploaded from other countries.

Conclusion: This study revealed that most videos lacked critical information regarding MRONJ. These omissions could significantly impact the quality of information available to the public.

Keywords: Awareness; Internet; Knowledge; Osteonecrosis; Quality

ÖZET

Amaç: Bu çalışmada YouTube™'daki MRONJ, MRONJ'la ilişkili durumlar ve komplikasyonlarla ilgili videoların içerdiği bilgileri değerlendirmeyi amaçlamaktadır. Mevcut literatür taramasında daha önce yapılmış benzer bir çalışmaya rastlanmamıştır.

Gereç ve Yöntem: Araştırma İngilizce dilindeki videolar üzerinden gerçekleştirildi. İlk 100 videodan 63 tanesi çalışmaya dahil edildi. Videolar 2 araştırmacı tarafından değerlendirildi. Değerlendirmeler etkileşim indeksi ve görüntülenme oranına göre hesaplandı.

Bulgular: Videoların çoğunluğu MRONJ ile ilgili temel bilgilere sahip olsa da 20'den azı ayırıcı tanı, semptomlar ve ilişkili diğer konularla ilgili bilgiler içermektedir. Üniversiteler ve hastaneler tarafından yüklenen videolar değerlendirmelerde diğer kaynaklardan yüklenen videolara göre daha yüksek puan almıştır. Ek olarak Amerika Birleşik Devletleri'nden yüklenen videolar hem Video Bilgi ve Kalite İndeksi hem de Kalite Değerlendirme Puanı değerlendirmesinde diğer ülkelerden yüklenen videolara önemli ölçüde daha düşük puan almıştır.

Sonuç: Yapılan bu çalışma videoların çoğunun içeriğinde MRONJ'la ilişkili önemli bilgilerin büyük oranda eksik olduğunu göstermiştir. Bu eksiklikler internetten düzgün bilgi almak isteyen insanlar için önemli bir rol oynamaktadır.

Anahtar Kelimeler: Bilgi; Farkındalık; İnternet; Kalite; Osteonekroz

Makale gönderiliş tarihi: 05.04.2024; Yayına kabul tarihi: 31.12.2024

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INTRODUCTION

Globally, osteoporosis and cancer represent significant public health issues. Treatment for a number of bone-resorbing disorders, including osteoporosis, cancer, multiple myeloma, Paget's disease, and osteogenesis imperfecta, involves the use of antiresorptive drugs. Neuroendocrine tumors, renal cell carcinomas, gastrointestinal tumors, and other cancers are treated using antiangiogenic medications.¹

Worldwide, one of the most frequently prescribed drugs is bisphosphonates (BPs). Every year, nearly 200 million prescriptions for BPs are filled. Although most side effects of BPs are well tolerated, they may be unpleasant. These include esophagitis, musculoskeletal pain, hypocalcemia, ocular inflammation, osteonecrosis of the maxilla and mandibula. Numerous cases resembling the initial 2003 report of BP-related osteonecrosis of the jaw (BRONJ) have been documented. Osteonecrosis of the jaw has been seen more recently in conjunction with antiangiogenic medicines and other treatments, including denosumab.²

In order to include all the medications that have been linked to the development of osteonecrosis of the jaw, the American Association of Oral and Maxillofacial Surgeons (AAOMS) has proposed changing the nomenclature of associated with BP use osteonecrosis of the jaw (BRONJ) to medication-related osteonecrosis of the maxilla and mandibula (MRONJ).

Three criteria form the basis of the current definition of MRONJ:

- Antiresorptive or antiangiogenic agent treatment, either current or past
- Bone exposed or accessible through an intraoral or/and extraoral fistula in the maxillofacial area that has remained stable for more than eight weeks
- There is no evident metastatic illness to the jaws or history of radiotherapy to the maxilla and mandibula.³

Necrotic bone is frequently observed during a patient's clinical examination, along with purulent discharge, fistulas, and symptoms of inflammation (redness, swelling). Patients may experience pain and have trouble speaking, eating, swallowing, or chewing, particularly if the necrotic mass contacts nerve

structures or is large enough to impair normal oral functioning. Fractures are also possible.⁴

The development of MRONJ appears to be linked to a number of risk factors. Systemic and local elements comprise this group of factors. Treatment duration and medication potency are examples of systemic variables. Dental extractions, implant placement, periapical surgery, and periodontal surgery are examples of local variables.⁵

Although several explanations have been put out, the pathophysiology of MRONJ remains unclear. The most significant factor is the suppression of osteoclasts.⁶ Various theories have been put forth to explain why MRONJ is specifically localized to the jaws. These theories include changes in bone remodeling or excessive inhibition of bone resorption and angiogenesis, persistent microtrauma, suppression of innate or acquired immunity, deficiency of vitamin D, toxicity to soft tissues from blood pressure, and inflammation or infection.³

According to the AAOMS, the goal of the current MRONJ treatment is to minimize or completely eradicate patient complaints. However, this treatment plan may not always produce the desired outcomes. Thus, in addition to the medical and/or surgical treatments for MRONJ, novel approaches and substances that are believed to have a beneficial effect on bone and soft tissue healing are being studied.^{3,7}

Information on healthcare is traditionally provided to patients by healthcare organizations and professionals. However, due to the Internet's increased accessibility, patients' desire for greater information, and the cheaper cost of web-based counseling in comparison to in-person healthcare consultation, there has been a significant increase in the public's use of the Internet for medical information over the past ten years. In addition to seeking information from medical professionals, patients use the Internet to gain insight into their diagnosis and even treatment.⁸

The online video-sharing website YouTube™ was founded in 2005. At the moment, YouTube™ is the second-most popular website globally.⁹ It's fairly typical for people to use internet resources to obtain medical information. Numerous medical specialties have researched using videos from YouTube™ for

patient education and health promotion.¹⁰

Since YouTube™ videos are not impartially assessed, viewers may discover inaccurate or deceptive information in these videos.¹⁰ Studies on several health conditions, including oral leukoplakia, oral cancer, Sjögren's syndrome, Covid-19, and Alzheimer disease, have recently assessed the quality of YouTube™ videos.¹¹

To our knowledge, no research has examined the content of YouTube™ videos on MRONJ. Since it is simple to obtain information of any kind and in any context via online videos, evaluate the credibility, adequacy, and correctness of YouTube™ videos connected to this topic in order to create an opinion regarding the precision of the knowledge that individuals have obtained.

MATERIALS AND METHOD

YouTube Search

In January 2021, the YouTube™ website was searched for videos on "MRONJ" by using the website's default configuration. Most viewers conducting an online search scan the first 60 to 200 videos, but the first 30 videos were typically scanned by the majority of YouTube™ viewers. The first 100 relevant videos were viewed and analyzed.

Selection of Videos

Initial screening of videos was evaluated to exclude videos in languages other than English, duplicate videos, videos without sound or a title, videos about alternative MRONJ treatments, satirical videos, irrelevant videos, and advertisements. 37 such videos were, therefore, excluded. The remaining videos were analyzed in terms of the accuracy and quality of the information they contained.

Analysis of Videos

A total of 63 videos were selected for analysis. The videos were viewed and analyzed independently by two researchers. (1) Number of views, (2) total video duration, (3) total number of comments, (4) likes and dislikes, (5) date of upload, (6) target audience and (7) country of origin were recorded for each video. Viewers' interactions were calculated based on the (8) interaction index (number of likes-number of dis-

likes/total number of views) and the (9) viewing rate (number of views/number of days since upload).

For each video, the source of upload was recorded and categorized as healthcare professionals, health companies and websites, individual viewers, universities, and hospitals.

In addition, each video was assessed in terms of the definition of MRONJ, risk factors, symptoms, differential diagnosis, prognosis, treatment, new therapeutic approaches, and complications and scored 1 or 0 whether each video addressed these or not. These scores were used to calculate the Video Information and Quality Index (VIQI). Also, all videos were rated between 1 to 5 about the flow of information, information accuracy, quality, and precision evaluations for calculation as Quality of Assessments (QAS).

Statistical Analysis

The NCSS (Number Cruncher Statistical System) 2007 (Kaysville, Utah, USA) was used for statistical analysis. The Shapiro-Wilk Test and descriptive statistical techniques (mean, standard deviation, median, frequency, ratio, minimum, and maximum) were used to assess data distribution. The quantitative data of two groups that do not exhibit a normal distribution and the quantitative data of three or more groups that do not exhibit a normal distribution were compared using the Mann-Whitney U test and the Kruskal-Wallis test, respectively. Paired data between two researchers were assessed for statistical significance using the Wilcoxon test. To ascertain the relationship between quantitative data, Spearman's correlation analysis was employed. The study has been examined through the significance thresholds were set at $p < 0.05$ and $p < 0.01$ for better evaluation of its accuracy.

RESULTS

After the initial analysis, 63 videos were included in the study. Many videos (38.1%, $n=24$) were uploaded by health companies and websites, and 23.8% ($n=15$) were uploaded by each of healthcare professionals and individual users, equally.

Most videos were uploaded by users from the United States (74.6%), and the rest were from other countries.

Although more than half of videos (55.6%) included definitions of MRONJ, indications of BPs and similar drugs (60.3%), medications that may cause MRONJ and other risk factors for MRONJ (79.4%), less than 20 out of 63 videos included symptoms (33.4%), differential diagnosis (9.5%), contraindications (25.4%), prognosis (23.8%), treatment options (30.2%), and new therapeutic approaches for MRONJ (14.3%).

The length of the videos ranged from 2.00 to 6754 seconds, while the number of likes were between 0 and 1000 and the dislikes ranged from 0 to 17. The range of the number of viewings was 4 to 54000. The mean value of VIQI was 10.5 (SD=5.1), and the mean value of QAS was 3.8 (SD=2.7). Other statistics are shown in Table 1.

There were statistically significant differences between the sources of the videos and both the total video duration and loading time.

Total video duration of the videos uploaded by healthcare professionals was significantly longer than that of the videos uploaded by individual users and shorter than that of the videos uploaded by universities and hospitals ($p=0.001$). The total video duration of the videos uploaded by health companies and websites was significantly longer than that of the videos uploaded by individual users ($p=0.001$). In addition, the total video duration of the videos uploaded by individual users was significantly longer than that of the videos uploaded by universities and hospitals ($p=0.001$) (Table 2).

The loading date of the videos that were uploaded by healthcare professionals and health companies

and website users was significantly older than that of the videos that were uploaded by individual users ($p=0.013$). Also, the loading date of the videos that were uploaded by universities and hospitals was significantly older than that of the videos that were uploaded by individual users ($p=0.013$) (Table 2).

There was a statistically significant correlation between the source of the video and the total quality assessment score ($p=0.047$). The total QAS value of the videos both uploaded by healthcare professionals and individual users was lower than that of the videos uploaded by universities and hospitals ($p=0.001$) (Table 3).

There was a statistically significant relationship between the country of origin of the video and both total video duration and loading date. The total video duration of the videos that were uploaded from the United States was significantly shorter than that of the videos uploaded from other countries ($p=0.004$). However, the loading date of the videos that were uploaded from the United States was significantly older than that of the videos uploaded from other countries ($p=0.005$) (Table 4).

There was a significant correlation between the country of origin of the video and the quality, total VIQI, and QAS scores (Table 5).

The quality score of the videos that were uploaded from the United States was significantly lower than that of the videos uploaded from other countries ($p=0.012$). In addition, both total VIQI and total QAS values of the videos that were uploaded from the United States were significantly lower than that of the videos uploaded from other countries (Table 5).

Table 1. The evaluation table of the videos

	Mean±SD*	Min-Max (Median)
Number of views	3195.4±8400.6	4-54000 (645)
Number of likes	45.3±144.4	0-1000 (6)
Number of dislikes	1.0±2.9	0-17 (0)
Number of comments	2.8±7.9	0-49 (0)
Total video duration (seconds)	1262.5±1663.8	2-6754 (558)
Loading time (days)	1348.1±1016.2	42-3896 (1088)
Interaction index	1.8±2.8	0-19.05 (0.89)
Viewing rate	300.7±784.3	0.77-5362.46 (81.29)
Total VIQI	10.5±5.1	0-20 (10)
Total QAS	3.8±2,7	1-10 (3)

*SD: Standard deviation

Table 2. Comparison of information and quality index of videos according to source of video

	Source of videos	N	Mean±SD*	Min-Max (Median)	p
Number of views	Healthcare professionals	15	4265.8±8133.3	381-31320 (1586)	0.098
	Health companies and websites	24	4434.7±11861	18-54000 (220)	
	Individual users	15	1639.7±2081.3	51-7912 (1005)	
	Universities and hospitals	9	699.3±900.7	4-2846 (293)	
Number of likes	Healthcare professionals	15	108.2±252.6	1-1000 (17)	0.070
	Health companies and websites	24	40.7±115.4	0-548 (7)	
	Individual users	15	11.4±17.4	0-53 (5)	
	Universities and hospitals	9	9.56±10.6	0-27 (5)	
Number of dislikes	Healthcare professionals	15	0.6±1.4	0-5 (0)	0.576
	Health companies and websites	24	1.79±4.34	0-17 (0)	
	Individual users	15	0.67±1.45	0-4 (0)	
	Universities and hospitals	9	0.22±0.44	0-1 (0)	
Number of comments	Healthcare professionals	15	8.47±14.4	0-49 (1)	0.131
	Health companies and websites	24	0.92±1.82	0-8 (0)	
	Individual users	15	1.47±3.82	0-15 (0)	
	Universities and hospitals	9	0.56±1.33	0-4 (0)	
Total video duration (seconds)	Healthcare professionals	15	610.5±419,1	102-1410 (481)	0.001**
	Health companies and websites	24	1806.4±2102.5	2-6754 (875.5)	
	Individual users	15	495.7±1005.9	20-3897 (131)	
	Universities and hospitals	9	2177.2±1714.1	363-4997 (1773)	
Loading time	Healthcare professionals	15	1226.9±673.1	194-2117 (1088)	0.013*
	Health companies and websites	24	1015±890.7	42-3231 (756.5)	
	Individual users	15	2163.1±1177.3	312-3896 (2483)	
	Universities and hospitals	9	1079.6±903,5	93-2517 (806)	
Interaction index	Healthcare professionals	15	2.18±1.99	0.18-7.36 (1.44)	0.071
	Health companies and websites	24	2.19±4.13	0-19.05 (0.8)	
	Individual users	15	0.74±0.96	0-3.38 (0.51)	
	Universities and hospitals	9	1.51±1.08	0-3.55 (1.77)	
Viewing rate	Healthcare professionals	15	468.8±799.9	26.14-3091.81 (136.31)	0.243
	Health companies and websites	24	376.4±1083.9	5.02-5362.46 (90.65)	
	Individual users	15	125.0±221.0	2.3-857.14 (47.44)	
	Universities and hospitals	9	111.7±125.2	0.77-395.47 (109.33)	

Kruskal Wallis Test; *p<0.05, **p<0.01. SD = Standard deviation

Table 3. Comparison of the quality assessment scores by the source of the video

	Source of videos	N	Mean±SD*	Min-Max (Median)	p
Flow of information	Healthcare professionals	15	2.93±1.1	2-5 (3)	0.260
	Health companies and websites	24	2.96±1.3	1-5 (3)	
	Individual users	15	2.33±1.45	1-5 (2)	
	Universities and hospitals	9	3.33±1.22	1-5 (4)	
Accuracy of Information	Healthcare professionals	15	3±1.31	1-5 (3)	0.129
	Health companies and websites	24	3.08±1.32	1-5 (3)	
	Individual users	15	2.27±1.39	1-5 (2)	
	Universities and hospitals	9	3.56±1.33	1-5 (4)	
Quality	Healthcare professionals	15	2.27±0.96	1-4 (2)	0.144
	Health companies and websites	24	2.63±1.1	1-5 (2)	
	Individual users	15	2±1.2	1-5 (2)	
	Universities and hospitals	9	3.11±1.54	1-5 (3)	
Precision	Healthcare professionals	15	2.27±1.22	1-5 (2)	0.096
	Health companies and websites	24	2.46±1.32	1-5 (2)	
	Individual users	15	1.8±0.94	1-4 (2)	
	Universities and hospitals	9	3.22±1.48	1-5 (3)	
Total VIQI	Healthcare professionals	15	10.47±4.1	5-17 (10)	0.135
	Health companies and websites	24	11.04±5.17	0-19 (10)	
	Individual users	15	8.2±5.06	1-17 (8)	
	Universities and hospitals	9	13.22±5.31	4-20 (14)	
Total QAS	Healthcare professionals	15	3.4±2.35	1-9 (3)	0.047*
	Health companies and websites	24	3.92±2.75	1-10 (3)	
	Individual users	15	2.8±2.15	1-8 (2)	
	Universities and hospitals	9	6.11±2.85	1-10 (7)	

Kruskal Wallis Test; *p<0.05, **p<0.01 SD = Standard deviation

Table 4. Comparison of the video information, and quality indexes by the country of origin of the video.

	Country of origin	N	Mean±Sd*	Min-Max (Median)	p
Number of views	United States	47	3378.5±8696.5	18-54000 (931)	0.212
	Other	16	2657.5±7703.7	4-31320 (310)	
Number of likes	United States	47	35.6±87.9	0-548 (8)	0.590
	Other	16	74.1±247.7	0-1000 (5)	
Number of dislikes	United States	47	1.28±3.3	0-17 (0)	0.284
	Other	16	0.25±0.58	0-2 (0)	
Number of comments	United States	47	2.28±5.71	0-27 (0)	0.922
	Other	16	4.31±12.35	0-49 (0)	
Total video duration (seconds)	United States	47	995.1±1510.4	2-6754 (363)	0.004**
	Other	16	2048.3±1887.7	184-6465 (1325.5)	
Loading time	United States	47	1549.5±1055.2	140-3896 (1446)	0.005**
	Other	16	756.3±594.1	42-1513 (736)	
Interaction index	United States	47	1.28±1.49	0-7.36 (0.66)	0.108
	Other	16	3.12±4.83	0-19.05 (1.64)	
Viewing rate	United States	47	292.3±803.7	2.3-5362.46 (79.27)	0.439
	Other	16	325.4±748.8	0.77-3091.81 (114.29)	

Mann Whitney-U Test; *p<0.05, **p<0.01 SD = Standard deviation

Table 5. Comparison of the quality of assessments scores by the country of origin

	Country of origin	N	Mean±Sd*	Min-Max (Median)	p
Flow of information	United States	47	2.72±1.26	1-5 (3)	0.184
	Other	16	3.25±1.34	1-5 (3)	
Accuracy of information	United States	47	2.74±1.36	1-5 (3)	0.055
	Other	16	3.5±1.27	1-5 (4)	
Quality	United States	47	2.26±1.17	1-5 (2)	0.012*
	Other	16	3.06±1.06	1-5 (3)	
Precision	United States	47	2.19±1.25	1-5 (2)	0.055
	Other	16	2.88±1.31	1-5 (3)	
Total VIQI	United States	47	9.77±4.98	0-19 (10)	0.044*
	Other	16	12.8±4.74	4-20 (13.5)	
Total QAS	United States	47	3.3±2.39	1-9 (3)	0.010*
	Other	16	5.44±2.94	1-10 (5.5)	

Mann Whitney-U Test; *p<0.05 SD = Standard deviation

Although there was no statistically significant difference between researchers' evaluations of videos' quality assessment scores ($p>0.05$), total QAS value had statistically significant difference between the first and second researchers ($p<0.01$) (Table 6).

The number of views had different correlations with all variables and these relationships were statistically significant ($p<0.01$), except total video duration, interaction index, flow of information, information accuracy, quality, precision, total VIQI and total QAS values.

Number of likes had significant positive correlations with the number of dislikes, number of comments, interaction index, and viewing rate ($p<0.01$).

There were moderately strong, significant positive correlations between the number of dislikes and both the number of comments and viewing rate ($p<0.01$).

There was weak and significant positive correlation between the number of comments and interaction rate, as well as moderately strong and significant positive correlation with the viewing rate ($p<0.01$).

There was a moderately strong, statistically significant negative correlation between total video duration and loading date ($p<0.01$). In addition, total video duration had a significant correlation with the rest of the parameters ($p<0.01$) except for the viewing rate.

Table 6. Comparison of the quality assessment scores of the videos assessed by the study researchers

	1st researcher	2nd researcher	p
Flow of information	Mean±SD*	2.86±1.29	2.9±1.21
	Min-Max (Median)	1-5 (3)	1-5 (3)
Accuracy of information	Mean±SD*	2.94±1.37	2.89±1.3
	Min-Max (Median)	1-5 (3)	1-5 (3)
Quality	Mean±SD*	2.46±1.19	2.49±1.2
	Min-Max (Median)	1-5 (2)	1-5 (2)
Precision	Mean±SD*	2.37±1.29	2.41±1.27
	Min-Max (Median)	1-5 (2)	1-5 (2)
Total VIQI	Mean±SD*	10.54±5.06	10.7±4.64
	Min-Max (Median)	0-20 (10)	4-20 (10)
Total QAS	Mean±SD*	3.84±2.68	4.35±2.33
	Min-Max (Median)	1-10 (3)	1-10 (4)

Wilcoxon Test; **p<0.01 SD = Standard deviation

Loading date had significant, negative and different levels of correlation with interaction rate, flow of information, accuracy of information, quality, precision, total VIQI and QAS score ($p < 0.05$).

There were significant positive correlations between the interaction rate and viewing rate, flow of information, accuracy of information, total VIQI and QAS values ($p < 0.05$).

There was no significant correlation between the viewing rate and the other scores.

Flow of information had significant, strongly positive correlations with the accuracy of information, quality, precision, total VIQI, and QAS scores ($p < 0.01$).

There were significant, strongly positive correlations between the accuracy of information and quality, precision, total VIQI, and QAS scores ($p < 0.01$).

Quality had significant, strongly positive correlations with precision, total VIQI, and QAS values ($p < 0.01$). The same relationship also existed between precision and both total VIQI and QAS scores ($p < 0.01$). Total VIQI score had a strongly positive correlation with total QAS score ($p < 0.01$).

DISCUSSION

Social media platforms are used by many people to reach information about their health-related concerns, treatment alternatives, and different healthcare professionals, hospitals and companies dealing with the disorders. The same platforms are also used by healthcare providers, companies, or individual users to inform or warn people about common health problems in a similar way.¹²⁻¹⁴ YouTube™ is one of the most popular social media platforms and used by many people to share videos about literally everything.¹⁵

Despite developing technology, the lack of control mechanisms on misinformation spread on this platform may cause confusion among people. Inexperienced users might be misled by a huge amount of data and lack of control.¹⁶⁻²⁰

Although there are various studies on YouTube™ videos about heart failure, asthma, mammography, prostate diseases, maxillofacial diseases, and other disorders, there is still no accepted standardized research and evaluation method available for these

kinds of studies.^{10,21-24}

MRONJ is term or a condition defined by AAOMS, which is caused by long-term use of certain drugs like BPs, denosumab, and other antiangiogenic drugs. These drugs can be prescribed for patients suffering osteoporosis, Paget's disease, and some types of cancers.² In addition, the incidence rate of these diseases has been increasing. A parallel increase has also been witnessed in the number of prescriptions of such medications. This means that patients need to have more clear information and awareness of the risk and possible complications of the use of these medications.^{25,26} In addition, YouTube™ is mostly the preferred platform to search for information about oral mucosa diseases by less or non-experienced clinicians and common users.^{11, 27,28}

Although there are numerous studies about oral diseases on YouTube™, only the present study evaluated the quality and quantity of videos on MRONJ.

The purpose of this study was to assess the usefulness, content quality, information level, and other properties of the videos about MRONJ on YouTube™ website.

The first most viewed 100 videos on YouTube™ were chosen for analysis; 37 of them were excluded because of exclusion criteria. Even 100 is a small number compared with other previously analyzed topics on YouTube™, such as oral lichen planus, oral leukoplakia, and oral cancer.^{11, 27,29}

The present study showed that more than 50% of the videos included knowledge about MRONJ, indications of the relevant drugs, induced medications and risk factors despite the fact that the majority of the videos did not include any information about symptoms, differential diagnosis, drug contraindications, prognosis, available treatments, and new therapeutic approaches of MRONJ. The missing contents may play an important role for providing accurate information.

The present study indicated that less than 50% of videos were uploaded by healthcare professionals or universities and hospitals. Our interpretation is that physicians working in hospitals or universities have no time to create and publish such videos owing to their workload.

Despite a lower number of video uploads by healthcare professionals, their videos got the highest number of views and likes. The videos with the longest total duration were uploaded by universities or hospitals while the shortest ones were uploaded by individual users. This indicates that universities and hospitals may have greater resources to prepare videos. In line with this information, although there was no statistically significant difference, the videos uploaded by hospitals or universities had the best flow of information, accuracy of information, quality, precision, and VIQI compared with other uploaders. Romano *et al.*²⁷, who studied the quality of YouTube™ videos on oral lichen planus, reported that university channels provided higher quality videos than others, as indicated by the present study and other studies.²⁷⁻³⁰

Providers from the US started to upload videos before other providers; they also uploaded most of the available videos. But the total duration of their videos were significantly shorter compared with that of other video providers. This suggests that providers from the US knew and warned about the risks of MRONJ previously than other providers; however, providers from the US uploaded shorter videos and had videos with lower total VIQI and QAS scores than other providers' videos. In addition to that, the videos uploaded by universities or hospitals had higher total QAS scores than those of the videos uploaded by other providers such as healthcare professionals, health companies and websites, and individual users. This suggests that professional institutions can convey correct information more properly than others.

There was a negative correlation between loading date and total VIQI and QAS scores. This may suggest that these scores are getting higher with developing technology and increasing knowledge and awareness about MRONJ. There was a positive and strong relationship between video quality and total VIQI and QAS scores. Additionally, and unsurprisingly, a similarly strong positive relationship was observed between total QAS and VIQI scores.

CONCLUSION

The present study indicated that social media platforms can be used by both healthcare professionals to reach a larger audience with relevant information, and by the public to obtain information on topics of

interest. Particularly for media aimed at providing medical information, there is a need for a control mechanism. Lack of control mechanism may cause people to upload inaccurate and insufficient information as pointed out by similar studies. As healthcare workers, we should be careful about sharing medical videos by keeping ourselves up-to-date with the most recent approaches on technology and medicine.

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Evaluation of the Role of the Bonwill Triangle in Temporomandibular Disorders: A Retrospective Analysis

Temporomandibular Bozukluklarda Bonwill Üçgeninin Rolünün Değerlendirilmesi: Retrospektif Analiz

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ABSTRACT

Aim: The aim of this study was to evaluate the role of the Bonwill triangle in temporomandibular disorders (TMDs).

Materials and Method: This study was conducted using 1880 cone beam computed tomography (CBCT) images obtained from the Department of Oral, Dental, and Maxillofacial Radiology Clinic at Nuh Naci Yazgan University Faculty of Dentistry between June 2020 and February 2024.

Results: A total of 154 patients were included in the study, with ages ranging from 18 to 45 years (mean age: 24.9 ± 5.8 years). Of these, 70 were male (45.5%), and 84 were female (63.0%). The control and TMD groups each comprised 77 patients. In the analyses, no statistically significant difference in the measurements examined was found between the TMD and control groups ($p > 0.05$). In males, the distance between the center of the right condyle and the center of the right mandible (IC-R) was found to be significantly higher compared to females ($p < 0.001$). Similarly, the distance between the center of the left condyle and the center of the left mandible (IC-L) was found to be significantly higher in males than in females ($p < 0.001$). Additionally, the intercondylar distance measurement was found to be significantly higher in males compared to females ($p < 0.001$). However, there was no statistically significant difference in the IC-R (right and left) and intercondylar distance measurement between the control and TMD groups ($p > 0.05$).

Conclusion: Limited information exists in the literature about the impact of the Bonwill triangle on TMD. Our findings suggested that TMD did not have a significant effect on these anatomical features. However, gender was found to have a significant effect. These results underscore the need for further research to develop a more comprehensive understanding of the pathophysiology of and treatment strategies for TMD.

Keywords: Cone beam computed tomography; Dental occlusion; Temporomandibular joint disorder

ÖZET

Amac: Bu çalışmanın amacı, Bonwill üçgeninin temporomandibular bozukluklar (TMB) üzerindeki etkisini değerlendirmektir.

Gereç ve Yöntem: Nuh Naci Yazgan Üniversitesi Diş Hekimliği Fakültesi'nde Haziran 2020 ile Şubat 2024 tarihleri arasında elde edilen 1880 konik ışın bilgisayarlı tomografi (KİBT) görüntüsü kullanılarak bu çalışma yürütülmüştür.

Bulgular: Çalışmada, toplam 154 hasta incelenmiştir, yaşları 18 ila 45 arasında değişmekte olup ortalama yaşları 24.9 ± 5.8 'dir. Bu hastaların 70'i erkek (%45.5) ve 97'si kadındır (%63.0). Kontrol grubunda 77 hasta bulunurken, TMD tanısı alan grubunda da 77 hasta bulunmaktadır. Yapılan analizlerde, TMD grubu ile kontrol grubu arasında incelenen ölçümlerde istatistiksel olarak anlamlı bir farklılık bulunmamıştır ($p > 0.05$). Erkeklerde, sağ kondilin merkezi ile sağ mandibular merkez arasındaki mesafe (IC-S) kadınlara göre istatistiksel olarak anlamlı derecede yüksektir ($p < 0.001$). Benzer şekilde, sol kondilin merkezi ile sol mandibular merkez arasındaki mesafe (IC-S) erkeklerde kadınlara göre anlamlı derecede yüksektir ($p < 0.001$). Ayrıca, interkondiler mesafe ölçümü erkeklerde kadınlara göre anlamlı derecede yüksektir ($p < 0.001$). Kontrol grubu ile TMD grubu arasında ise IC-S (sağ ve sol) ve interkondiler mesafe ölçümlerinde istatistiksel olarak anlamlı bir farklılık bulunmamıştır ($p > 0.05$).

Sonuç: Bonwill üçgeninin TMD üzerindeki etkisi hakkında literatürde sınırlı bilgi bulunmaktadır. Bu çalışmanın sonuçları, TMD'nin bu anatomik özellikler üzerinde belirgin bir etkisi olmadığını göstermektedir. Ancak cinsiyetin bu ölçümler üzerinde belirgin bir etkisi olduğu bulunmuştur. Bu bulgular, TMD'nin patofizyolojisi ve tedavi stratejileri üzerine daha derinlemesine bir anlayış geliştirmek için daha fazla araştırmanın gerekliliğini vurgulamaktadır.

Anahtar Kelimeler: Diş oklüzyonu; Konik ışınlı bilgisayarlı tomografi; Temporomandibular eklem bozuklukları

Makale gönderiliş tarihi: 24.04.2024; Yayına kabul tarihi: 17.03.2025

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INTRODUCTION

Temporomandibular dysfunction, also known as temporomandibular joint (TMJ) dysfunction or temporomandibular disorder (TMD), is a common condition affecting individuals of all age groups.¹ It encompasses a range of musculoskeletal conditions that occur in the temporomandibular region that lead to symptoms like pain, clicking, crepitus, and limitations in mandibular movement.² TMD presents with headaches, TMJ pain, and other related symptoms.³ The relationship between the mandible and the skull is crucial in the context of TMD: The mandible plays a significant role in mastication and speech, and any dysfunction in the TMJ can lead to limitations in mandibular movement and orofacial pain.⁴ TMD can be influenced by various factors, including parafunctional behaviors like bruxism, which may contribute to tooth wear but may not always have a significant relationship with TMJ dysfunction.⁵

An equilateral triangle, described by the American dentist G. Bonwill in 1858, formed the basis of Bonwill's theory of occlusion. Bonwill created this theory by measuring 6000 skulls and 4000 living individuals.⁶ The Bonwill triangle is formed by drawing lines between the mandibular incisors and the right and left mandibular condyles. This equilateral triangle shows that the ideal arch is symmetrical. The distance between the mandibular incisors and condyles, or the distance between the right and left condyles, varies significantly between men and women.⁷ The Bonwill triangle has significant effects on complete dentures, dental occlusion, articulation, and mandibular fractures. However, Bonwill's theory is rarely used since it contains a statement about simpler methods to correct problems with the mandible. Specifically, this theory states that the lengths of the teeth are in constant relationship with the other bones of the skull and the entire anatomical structure of the body, as well as the distance of the sides of the triangle.⁶

Proper occlusion is essential for maintaining the stability of the dental arch and distributing functional loads evenly across the TMJ. When there is a correct relationship between the maxillary bone and the jaw, with uniform and simultaneous dental contacts, the jaw gains maximum stability, and the TMJ remains asymptomatic. Conversely, occlusal imbalances can lead to increased loads on TMJ structures, potentially contributing to TMJ disorders.⁸

A literature review revealed that there was no study examining the relationship between occlusion and TMDs through the lens of the Bonwill triangle theory, which forms the basis of occlusion and is recommended for use in assessing mandibular problems. The aim of this study was thus to compare the Bonwill triangles of patients diagnosed with TMDs with those of healthy individuals.

MATERIALS AND METHOD

Sample Selection

This study was conducted using 1880 cone beam computed tomography (CBCT) images obtained from the Department of Oral and Maxillofacial Radiology at the Faculty of Dentistry between June 2020 and February 2024. The Ethics Boards and Commissions approved this work (2024/003-04).

The CBCT images of patients who presented with TMJ complaints and underwent TMJ tomography for further examination, as well as the CBCT records of patients who underwent tomography before third molar surgery, were randomly selected from the records.

The diagnosis of temporomandibular joint dysfunction is determined by oral and maxillofacial surgeons using the DC/TMD diagnostic criteria. The decision to perform tomography is made based on the DC/TMD diagnostic decision tree. In accordance with the inclusion and exclusion criteria of the study, CBCT scans were retrospectively analyzed, and the tomographic images of 154 patients were included in the study.

The inclusion criteria were as follows:

1. Patients had to be aged 18 years or older.
2. Patients had to have undergone TMJ tomography (research group), or they had to have undergone tomography for third molar extraction without TMJ complaints (control group).

Exclusion criteria included:

1. Patients with systemic muscle-joint diseases.
2. Patients with autoimmune disorders.
3. Patients who received radiotherapy to the head and neck region.
4. Patients who had undergone prolonged steroid therapy.

5. Patients who had undergone surgery in any joint of the body.
6. Patients with a history of orthognathic surgery and orthodontic treatment.
7. Patients whose CBCT images obtained for measurements lacked clarity in certain sections.

Acquisition of Images

The same X-ray technician performed all CBCT scans. Standing and biting on the positioning rod, the patient was placed such that their head was in neutral position, their midline was in the middle, and their horizontal plane was parallel to their cantho-meatal plane during the X-ray. To obtain the CBCT images, a 3D digital imaging system (KaVO OP 3D Pro, PaloDEX Group Oy, Tuusula, Finland) with pre-set settings and procedures was utilized. The KaVO OP 3D Pro CBCT tomographic scanner was configured with the following exposure settings applied to the chosen saved images in this investigation: 13 x 15 cm field of view, 90 kV exposure setting, 08 mA exposure duration, 17.5 to 26.9 s exposure period, and 0.320 mm voxel size.

Image Analysis

Image reconstruction and measurement were conducted using Cybermed's OnDemand 3D Imaging software (Seoul, South Korea). In the obtained pictures, 1 mm thick slices were made at the cervical vertebral level and the cranial base.

Determination of the Bonwill Triangle

Measurements were conducted following the methodology that Koothati *et al.*⁷ described. Accordingly, the axial sections of the CBCT images were used to evaluate the measurements of the Bonwill triangle as follows: Initially, the distance between the central points of the right and left mandibular condyles (C-LR) were measured in millimeters, following which the distance in millimeters between the contact point (IC) of the mandibular central incisors and the central points (R: Right condyle and L: Left condyle) of each condyle were measured (Figure 1).

C-LR, IC-Right, and IC-Left values were measured for each patient (Figure 2).



Figure 1. Determination of the contact point of mandibular incisors



Figure 2. Determining the Bonwill triangle

Statistical Analysis

The ideal sample size was determined using G-Power 3.1.9.7. With an effect size of 0.5 (moderate effect size), a power of 0.90, and an α of 0.05, the sample size was calculated to be 140. Hence, 70 CBCT images were examined for patients with TMJ diagnoses and 70 for patients in the control group.

TURCOSA (Turcosa Analytics Ltd Co, Turkey, www.turcosa.com.tr) online software was used in the statistical evaluation of the data obtained in our research. The existence of a linear relationship between variables was evaluated with Pearson's or Spearman's correlation test, depending on the distribution feature of the variable. Student's t-test was used to evaluate the data in the TMD and control groups. For the analyses, the statistical significance level was acceptable at $p < 0.05$.

RESULTS

Upon conducting an archive search, 90 TMJ CBCT images for the diagnosis of TMD were obtained.

After examining the data, 13 cases with TMJ were excluded from the study due to poor CBCT image

quality in the relevant sections. Subsequently, the records of 77 patients were selected for the TMD group, and the records of another 77 patients were chosen for the control group, and included in data analysis.

The study included a total of 154 patients, with ages ranging from 18 to 45 years and a mean age of 24.9 ± 5.8 years. Of these, 70 were male (mean age 23.8 ± 5.7), and 84 were female (mean age 25.5 ± 5.7), whose CBCT images were included for analysis (Table 1).

Analysis of the IC-Right measurement revealed that the mean value for males (97.1 ± 6) was significantly higher than that for females (91.7 ± 4.7) ($p < 0.001$). Similarly, for the IC-Left measurement, males exhibited a significantly higher mean value (96.2 ± 6.8) than females (91.7 ± 4.8) ($p < 0.001$). Additionally, an analysis of the intercondylar distance measurement showed that the mean value for males (103 ± 6.5) was significantly higher than for females (98.6 ± 5.6) ($p < 0.001$). (Table 2)

However, no statistically significant differences were found in the IC-Right ($p = 0.784$), IC-Left ($p = 0.307$), and intercondylar distance measurements ($p = 0.632$) between the control and TMD groups (Table 3).

Table 1. Descriptive statistics and frequencies of the group of patients with temporomandibular disease and the control group in terms of age and gender

		Control (n=77)	TMD (n=77)	Total (n=154)
Age	Mean \pm SD	23.7 ± 4.1	26.1 ± 6.9	24.9 ± 5.8
Gender				
Male	n (%)	34 (48.6)	36 (51.5)	70 (45.4)
Female	n (%)	43 (51.2)	41 (48.8)	84 (54.6)

n: Number of patients, TMD: Temporomandibular disorder, SD: Standard deviation

Table 2. Evaluation of measurement values according to gender

		Male (n=70)	Female (n=84)	p ^a
IC-Right	Mean \pm SD	97.1 ± 6	91.7 ± 4.7	<0.001*
IC-Left	Mean \pm SD	96.2 ± 6.8	91.7 ± 4.8	<0.001*
ID	Mean \pm SD	103 ± 6.5	98.6 ± 5.6	<0.001*

n: Number of patients, SD: Standard deviation, IC-Right: Distance between incisal edge and right condyle center, IC-Left: Distance between incisal edge and left condyle center, ID: Intercondylar distance, ^a: Student-t test, *: $p < 0.05$

Table 3. Comparison of measurement values of patients with temporomandibular disease and the control group

		Control (n=77)	TMD (n=77)	p ^a
IC-Right	Mean \pm SD	94 ± 6.6	94.3 ± 5.3	0.78
IC-Left	Mean \pm SD	93.9 ± 6.5	93.6 ± 5.9	0.76
ID	Mean \pm SD	100.9 ± 6.3	100.4 ± 6.5	0.63

n: Number of patients, TMD: Temporomandibular disorder, SD: Standard deviation, IC-Right: Distance between incisal edge and right condyle center, IC-Left: Distance between incisal edge and left condyle center, ID: Intercondylar distance, ^a: Student-t test

DISCUSSION

The aim of this study was to investigate the relationship between occlusion and TMDs through the lens of Bonwill's triangle theory, which serves as the basis for understanding occlusal harmony and mandibular function. Using CBCT images, we compared the Bonwill triangle measurements of patients diagnosed with TMD with those of healthy individuals. Herewith, we aimed to provide insights into the potential association between occlusal parameters and TMDs, clarifying diagnostic and treatment approaches in clinical practice.

The Bonwill triangle's height-to-base ratio reflects the symmetry of the mandible's left and right sides. Bilateral symmetry not only aids in aesthetic, expressive, linguistic, and masticatory oral functions but also helps maintain the stability and health of the entire oral and jaw system by equalizing the stress on the muscles and joints of both sides.⁹

The Bonwill triangle has been evaluated for various purposes related to medicine and dentistry, including gender determination, sex identification in forensic dentistry, anthropological studies, bone grafts, and the evaluation of mandibular fractures.^{7,10,11} The triangle has been particularly useful in providing geometric parameters for fractured mandibles and dental procedures.¹¹ Additionally, research has focused on using Bonwill triangle parameters to determine biological sex via CBCT⁷, while it has also been employed to assess occlusal vertical dimension changes in dental articulation studies.¹² In the field of dentistry, the Bonwill-Hawley method has been used for dental crowding measurements, demonstrating its applicability in orthodontic assessments.¹³

Reviewing the literature revealed that an assessment of the Bonwill triangle has been applied in various medical and dental areas; however, the relationship between the Bonwill triangle and TMD has not been explored sufficiently. Therefore, our study aimed to compare the Bonwill triangles of patients diagnosed with TMD and those of patients without TMJ complaints.

When reviewing much older studies, it was determined that the height of the Bonwill triangle is not affected by the selection of condylar reference points.¹⁴ Additionally, research on the impact of the

Bonwill triangle on complete dentures has highlighted its significance in prosthetic applications.¹⁵ Based on this information, it has been speculated that the Bonwill triangle may influence TMD in terms of occlusal stability.¹⁶⁻²⁰

Our study results showed that there was no statistically significant difference in the anatomical measurements examined between the control group and the TMD group. These results indicate that these measurements were similar between both groups and that TMD did not have a significant effect on these anatomical features.

Ganesh and Mohanraj⁶ reported the IC-right distance as 97.8 ± 2.8 , IC-left distance as 98.6 ± 3.8 , and intercondylar distance as 97.4 ± 3.4 in the measurements they took on 60 dry human mandibles. In this study, we found the IC-right distance as 94.3 ± 5.3 , IV-left distance as 93.6 ± 5.9 , and intercondylar distance as 100.4 ± 6.5 in patients with TMD. In the control group, we found the IC-right distance as 94 ± 6.6 , IV-left distance as 93.9 ± 6.5 , and intercondylar distance as 100.9 ± 6.3 . Although there was no statistical difference between these two groups in our study, it differs from the results of the study by Ganesh and Mohanraj. Our study has the advantage of providing a comparison between groups such as gender and joint diseases, however, since it is a radiological study, the image distortion factor is not eliminated and therefore it has a disadvantage compared to the one-to-one measurement obtained from the dry human mandible.

Stamm *et al.*²¹ made a comparison between skeletal class I, class II and class III patients on radiological data by taking the Bonwill triangle as a reference and found the distance of the incisors to the condyle center as 105.4 ± 5.7 in the Class I group, 92.1 ± 5.3 in the Class II group and 92.9 ± 5.9 in the Class III group. Ye *et al.*⁹ made a comparison between individuals with low, medium and high facial profiles by calculating the ratio of the Bonwill triangle to the intercondylar distance correction on radiological images and reached an evaluation regarding occlusion. Since our study was retrospective, we did not have information about the soft tissue profile of the patients. Therefore, we could not make a comparison between the groups according to their facial profiles.

These findings are important for clinical practice and treatment strategies since they can aid in developing a more in-depth understanding of the etiology and treatment of TMD.

Our study results, in line with the literature, show that gender has a decisive effect on these two measurements ¹¹, as well as on joint space measurements.

The primary limitation of our study is the retrospective evaluation of the data. Additionally, multicenter prospective clinical studies are required to generalize the study findings to the broader population.

CONCLUSION

While there is literature providing crucial insights into the impact of gender on anatomical measurements and has underscored the importance of considering gender-based differences in treatment strategies, there is a scarcity of research specifically addressing the Bonwill triangle in TMDs. Some studies have explored the relationship between occlusion and TMD, but the significance of the Bonwill triangle within this context remains relatively unexplored. Existing literature on occlusion and TMD presents conflicting views on the role of dental occlusion as an etiological factor in TMD. Further research is needed to elucidate the role of the Bonwill triangle in TMD pathogenesis and its potential implications for treatment approaches so that more tailored interventions can be formulated for individuals with TMD.

Conflicts of Interest Statement

There is no conflict of interest to declare.

Data Availability Statement

The datasets created and analyzed during the current study are available from the corresponding author upon request.

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Comparing Anthropometric and Quality Assurance Phantoms in Quantitative Image Quality Testing for CBCT Imaging

KIBT Görüntüleme Kantitatif Görüntü Kalitesi Testleri İçin Antropometrik ve Kalite Güvence Fantomlarının Karşılaştırılması

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Songül Çavdar Karaçam⁴, Kaan Orhan⁵, Mustafa Demir⁶

ABSTRACT

Aim: This study aims to imaging an anthropometric phantom and a quality assurance (QA) phantom with cone-beam computed tomography (CBCT) in three different dose protocols and to compare the quantitative image quality test values calculated with the anthropometric phantom with the QA phantom results in selected slices. Thus, it is aimed to produce information regarding the validity of image quality tests performed with anthropometric phantom slices.

Materials and Method: Alderson-Rando® phantom (Radiology Support Devices, Long Beach, CA) and QA phantom (QR Verona, Italy) were imaged with a MyRay Hyperion X9 Pro (Cefla, Imola, Italy) KIBT device. The field of view was chosen as 13x10 cm and three different imaging modes (Low Dose, Normal, High Quality) were implemented while keeping other parameters constant. Three slices were selected from the anthropometric phantom volumes (paranasal sinus, maxilla, mandible) and one slice from the QA phantom. A total of 12 image samples were imported into ImageJ software for signal-to-noise ratio and contrast-to-noise ratio calculations. Differences between three or more variables (Low Dose, Normal, High Quality, or paranasal sinus, maxilla, mandible and QA phantom slices) were evaluated by Kruskal-Wallis test, while the relationship between pairs of variables was analyzed by Spearman and Kendall's rank correlation coefficient. The statistical significance threshold was set as $p < 0.05$.

Results: The differences between the selected slices (paranasal sinus, maxilla, mandible, QA) and imaging modes (Low Dose, Routine, High Quality) were both statistically insignificant. According to Spearman's ρ , the correlation between QA phantom and maxillary and mandibular slices was statistically significant. SNR values for maxillary and mandibular slices were calculated between 12.6 and 23.1 for anthropometric phantom slices and between 16.2 and 23.3 for QA phantom slices. The CNR values were between 13.2 and 88.5 for the respective anthropometric phantom slices and 15.5 and 20.6 for the QA phantom.

Conclusion: The results of this study support that the measurements made with anthropometric phantom slices for image quality testing in CBCT are similar to those made with the QA phantom in the maxilla and mandible regions. Future studies with different phantom types, imaging systems and radiographic parameters may be considered to produce information about the advantages and disadvantages of the two phantom types in image quality testing.

Keywords: Cone-beam computed tomography; Quality control; Radiology

ÖZET

Amaç: Bu çalışmanın amacı, bir antropometrik fantom ve bir kalite güvence (KG) fantomunun konik-ışınli bilgisayarlı tomografi (KIBT) ile üç farklı doz protokolünde görüntülenmesi ve seçilen kesitlerde antropometrik fantom ile hesaplanan kantitatif görüntü kalitesi testi değerlerinin KG fantomu sonuçlarıyla kıyaslanmasıdır. Böylece, antropometrik fantom kesitleriyle yapılan görüntü kalitesi testlerinin geçerliliği hakkında bilgi üretimi hedeflenmektedir.

Gereç ve Yöntem: Alderson-Rando® fantomu (Radiology Support Devices, Long Beach, Kaliforniya) ve KG fantomu (QR Verona, İtalya) MyRay Hyperion X9 Pro (Cefla, Imola, İtalya) KIBT cihazı ile görüntüldü. Görüş alanı 13x10 cm olarak seçildi ve diğer parametreler sabit tutulurken üç farklı görüntüleme modu (Düşük Doz, Normal, Yüksek Kalite) uygulandı. Antropometrik fantom hacimlerinden üçer kesit (paranasal sinüs, maksilla, mandibula) ve KG fantomundan bir kesit seçildi. Toplam 12 görüntü örneği sinyal-gürültü oranı ve kontrast-gürültü oranı hesaplamaları için ImageJ yazılımına aktarıldı. Üç ve daha fazla değişken (Düşük Doz, Normal, Yüksek Kalite, veya paranasal sinüs, maksilla, mandibula ve KG kesitleri) arasındaki farklar Kruskal-Wallis testi ile değerlendirilirken sürekli değişken çiftleri arasındaki ilişki Spearman ve Kendall'ın sıra korelasyon katsayısı ile analiz edildi. İstatistiksel anlamlılık eşiği $p < 0.05$ olarak belirlendi.

Bulgular: Seçilen kesitler (paranasal sinüs, maksilla, mandibula, KG) ve görüntüleme modları (Düşük Doz, Rutin, Yüksek Kalite) arasındaki farkların her ikisi de istatistiksel olarak anlamsız bulundu. Spearman's ρ göre, KG fantomu ile maksiller ve mandibular kesitler arasındaki ilişki istatistiksel olarak anlamlı bulundu. Maksilla ve mandibula kesitleri için SNR değeri, antropometrik fantom kesitlerinde 12.6-23.1 arasında, KG fantomda ise 16.2-23.3 arasında hesaplandı. CNR değeri ise, ilgili antropometrik fantom kesitlerinde 13.2-88.5 arasında, KG fantom için ise 15.5-20.6 arasında bulundu.

Sonuç: Bu çalışmanın sonuçları, KIBT'de görüntü kalitesi testi için antropometrik fantom kesitleri ile yapılan ölçümlerin KG fantomu ile yapılanlara maksilla ve mandibula bölgelerinde benzer olduğunu destekler. İleride farklı fantom tipleri, görüntüleme sistemleri ve radyografik parametrelerle yapılacak çalışmalarla, görüntü kalitesi testlerinde iki fantom tipinin avantaj ve dezavantajları hakkında bilgi üretimi düşünülebilir.

Anahtar Kelimeler: Kalite kontrol; Konik-ışınli bilgisayarlı tomografi; Radyoloji

Makale gönderiliş tarihi: 11.09.2024; Yayına kabul tarihi: 08.03.2025

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INTRODUCTION

Cone-beam computed tomography (CBCT) is a technique commonly used in dentistry for diagnosis and treatment planning, as well as in interventional radiology and radiotherapy. For image quality tests on the relevant devices, common tests can be applied for different device types, and specific tests may be required depending on the device type and purpose.¹ Quality assurance (QA) guidelines for CBCT include recommendations on principles of use, indications, dose optimization, commissioning, and periodic testing. Specific QA phantoms are often required for quantitative image quality testing. However, the need for improvement in QA phantoms for CBCT imaging is discussed in the literature. Although phantoms produced for computed tomography (CT) are commonly used in image quality assessment, this has limitations in tests requiring higher resolution and simulation of metal artifacts. In addition, CT phantoms for soft tissue have limited utility in CBCT. Overall, there is a need for a universal CBCT QA phantom that can be used in different CBCT devices and with which test results can be compared.¹⁻⁴

Recent studies have assessed various image quality parameters such as artifacts, spatial resolution, image uniformity, and geometric accuracy using different types of phantoms, including water phantoms, manufacturer-provided phantoms, and phantoms developed by researchers. Polymethyl methacrylate (PMMA) phantoms, in particular, have been recognized as effective tools in image quality testing. However, not all developed phantoms meet the strict criteria required for comprehensive quality assessment, highlighting the ongoing need for innovation in phantom design.⁴⁻⁶

An anthropometric phantom is made of synthetic material that simulates the human anatomy and tissue composition in slices. It is used in dose calculations in radiation practices by placing dosimetry equipment in the holes formed in the slices. After physically simulating the relevant radiation application using phantoms, the measurements of dosimetry equipment are calculated, and these data are evaluated for risk calculation and dose optimization.⁷⁻¹⁰ In diagnostic imaging studies, radiographic data acquisition, which represents the internal composition of the anthropometric phantom, is performed during

the experiment.¹¹ Although QA phantoms are routinely used for image quality testing, the question of whether the volumes acquired with an anthropometric phantom can be used in similar image testing may be worth investigating.

This study aims to compare the quantitative image quality tests conducted with anthropometric and QA phantom in dental CBCT imaging. The null hypothesis is that the difference between the quantitative image quality tests performed with anthropometric phantom and QA phantom is statistically significant. Rejection of the null hypothesis can be considered to support the suggestion that the two phantoms are interchangeable in CBCT for image quality tests with limitations of each type.

MATERIAL AND METHOD

In this study, an anthropometric phantom and a QA phantom were imaged with a dental CBCT device in three different imaging protocols, namely "Low Dose," "Regular" and "Best Quality" modes, and quantitative image quality tests were performed on selected slices to be compared. Ethics committee approval was not obtained as this study did not involve human subjects.

Preparing the Samples

The Alderson-Rando® phantom (Radiology Support Devices, Long Beach, CA) simulating an average adult female (155 cm, 50 kg) was used to imitate soft and hard tissues (Figure 1). The first twelve of the horizontally oriented slices (2.5 cm thick) representing the head and neck region were fixed with nylon rods passing through the edges of the center section. Dosimetry equipment was not placed, and the top aluminum plate was not attached to avoid the metal artifacts. During imaging, a natural spine posture in phantom position and a Frankfort horizontal plane parallel to the ground were verified. Chin and head fixation apparatus were used to stabilize the phantom's head, whereas the bite stick was not employed. The QA phantom (QR Verona, Italy) which contains aluminum cylinder inside (Figure 2) was used as the control phantom. Both the anthropometric phantom and the QA phantom were placed on a BS-500 adjustable monitor stand (Millenium, Treppendorf, Germany) to reach the gantry. The QA phantom was raised for an extra ten cm with a card-

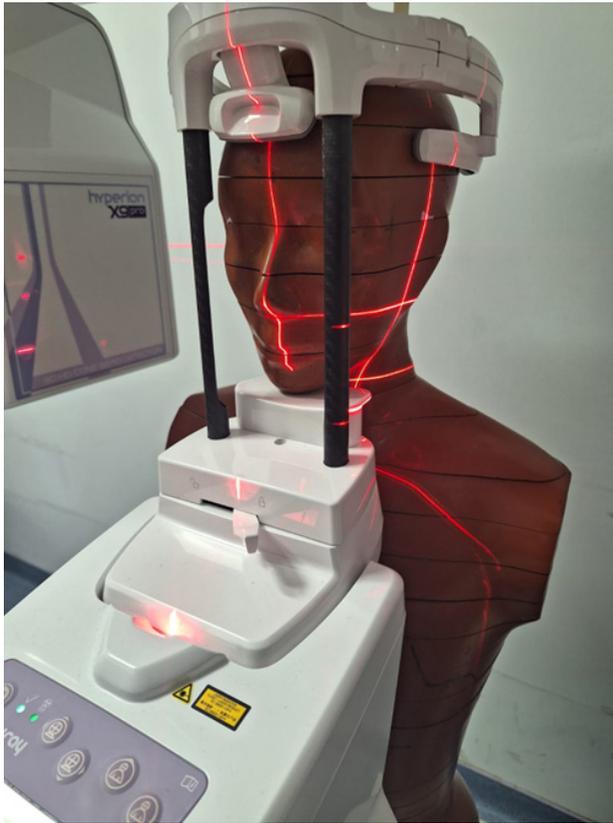


Figure 1. The Alderson-Rando® phantom (Radiology Support Devices, Long Beach, CA) is molded of tissue-equivalent material and routinely used for organ dosimetry measurements. In this study, slices selected from the volume reconstructed with CBCT irradiation were used for quantitative image quality tests.

board box to move away from the metal surface of the supporting platform. The position of the phantoms was visually checked using the Class I (IEC 60825-1:2014) laser.

Radiographic Volume Acquisition

The MyRay Hyperion X9 Pro (Cefla, Imola, Italy) CBCT machine with tele-radiographic/cephalometric arm was operated with 230V and 50 Hz electrical input (CEI OPX/105-12, IEC 60336). The X-ray was generated at 90 kVp ($\pm 5\%$) fixed pulsed beam, and mA was modulated in real-time with Automatic Morphology Recognition Technology (MRT) during volume acquisition. Field of View (FOV) was set to 13x10 cm (diameter x height) in all volume acquisitions, and vertical stitching was not required. The anthropometric phantom and QA phantom were imaged by using three different protocols: “Low Dose”

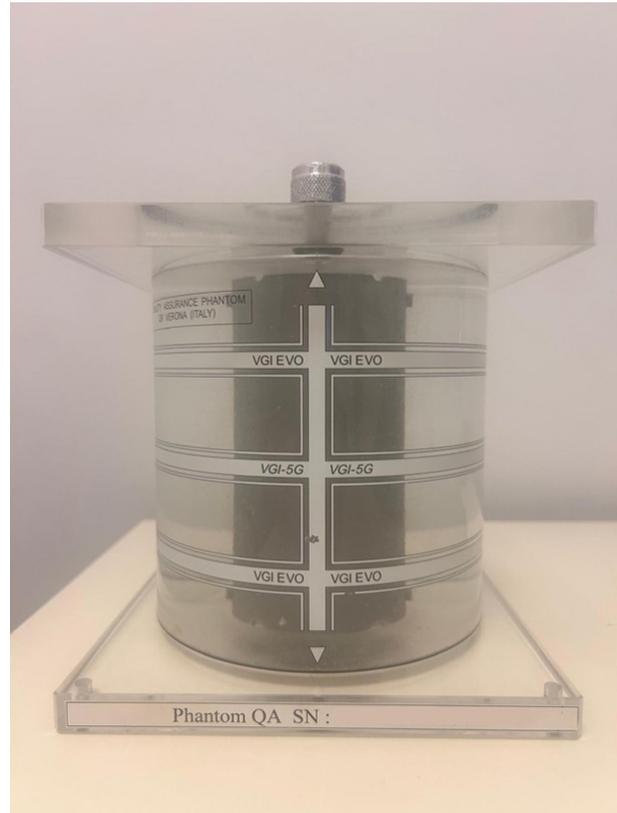


Figure 2. The QA phantom (QR Verona, Italy) which contains aluminum cylinder inside was used as the control phantom.

as 12.96 s (2.4 s exposure time), “Regular” as 14.4 s (3.6 s exposure time) and “Best Quality” as 16.8 s (5.2 s exposure time) rotation time. The amorphous silicon/cesium iodide flat panel detector was used for radiation acquisition. The signal was transferred to the HP Z2 Tower G4 Workstation (Intel® Xeon® E-2174G, 16 GB RAM, AMD Radeon Pro WX3100 (4 GB GDDR5, 10-bit) GPU) after 16-bit (65.535 gray levels) analog-to-digital conversion and volumes are reconstructed with the iRYS v15.0 software. For the three different imaging protocols, three axial slices representing the mandible, maxilla, and paranasal sinus regions were selected in the anthropometric phantom volumes, whereas in the QA phantom, a single slice with a clearly visible radiopaque layer was selected (Figure 3). Selected slices were exported in DICOM format and prepared for image quality tests.

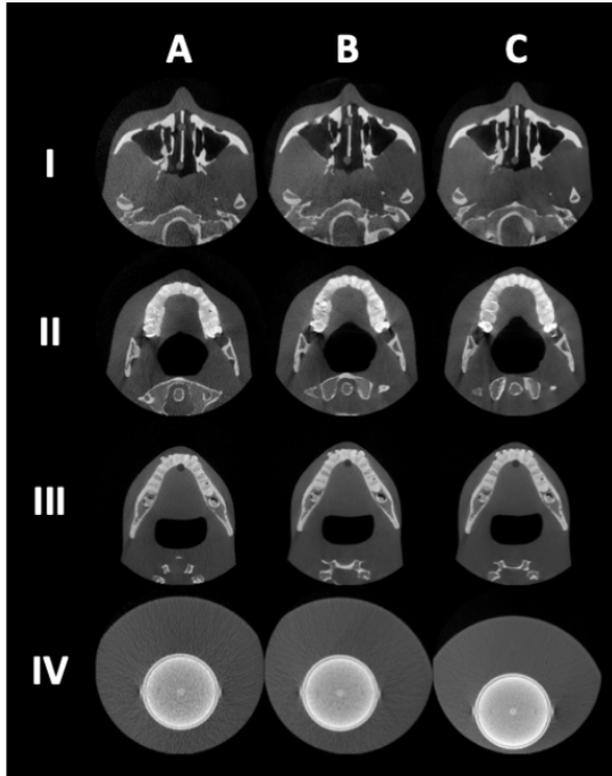


Figure 3. CBCT slices selected for image quality tests. I: Paranasal Sinus, II: Maxilla, III: Mandible, IV: Quality Assurance Phantom. A: Low Dose, B: Regular, C: Best Quality

Quantitative Image Quality Tests

The samples were imported to the ImageJ software, and three circular regions-of-interest (ROIs) 3x3 mm in size were selected to represent two contrast regions: the bone and the soft tissue. The size of the ROI was determined as the largest possible area, excluding other tissues when sampling bone and soft tissue regions in all slices. The ROIs were jointly selected by two dentomaxillofacial radiologists with nearly 10 years of experience, while randomly and equally distributed samples were validated by more experienced experts in dentomaxillofacial radiology, radiation oncology medical physics and nuclear medicine and medical imaging. The mean gray value in each ROI was combined with two other ROIs representing the relevant site to calculate the mean and standard deviations for bone and soft tissue for three different imaging protocols, at three different vertical heights on anthropometric phantoms, and on a single slice of the QA phantom. Signal-to-noise (SNR) and contrast-to-noise (CNR) values were calculated using the following formulas in MS Excel.^{2,3}

$$\text{SNR} = \frac{\text{MGV (bone)}}{\text{SD (soft tissue)}} \quad (1)$$

$$\text{CNR} = \frac{\text{MGV (bone)} - \text{MGV (soft tissue)}}{\text{SD (soft tissue)}} \quad (2)$$

MGV: Mean gray value, SD: Standard deviation

Statistical Analysis

The fit to normal distribution was assessed by the Shapiro-Wilk test. Non-parametric tests were chosen when the normality assumption was not met. The Wilcoxon Signed Rank Test was used to assess whether the mean ranks of SNR and CNR differ significantly. The Kruskal-Wallis test was performed to compare the median scores of three or more independent groups (Low Dose, Regular, and Best Quality; or Paranasal Sinus, Maxilla, Mandible, and QA Phantom). The Friedman Test was used to compare the measures of scores across three anatomical regions (Paranasal Sinus, Maxilla, and Mandible). Spearman's rank correlation coefficient (ρ) was used to assess the strength and direction of the monotonic relationship (2-tailed) between two variables: phantom and anthropometric phantom slices. Kendall's rank correlation coefficient (τ) was also performed to further validate the association between the QA phantom and the anatomical slices. Statistical significance threshold was determined as $p < 0.05$.

RESULTS

According to the MRT results, for anthropometric phantom experiments, the mAs value was determined as 7 (3 mA) in "Low Dose", 11 (3 mA) in "Regular" and 24 (4 mA) in "Best Quality" modes. For the QA phantom, the mAs value was determined as 7 (3 mA) in "Low Dose", 14 (4 mA) in "Regular" and 36 (7 mA) in "Best Quality" modes.

The Wilcoxon Signed Rank Test showed that the differences between SNR and CNR values were statistically significant ($p=0.03$). The Kruskal-Wallis test revealed that differences in SNRs and CNRs among paranasal sinus, maxilla, mandible, and QA slices ($p=0.39$) or imaging protocols ($p=0.37$) were not statistically significant (Table 1). Accordingly, the lowest measurements calculated on the QA phantom (SNR=16.2, CNR=15.5) were obtained

in the “Low Dose” protocol, while the highest values (SNR=23.3, CNR=20.6) were calculated in the “Best Quality” mode. “Regular” mode was found to be in between (SNR=19.1, CNR=17.6) the other two protocols. In the anthropometric phantom slices, a gradual increase was observed in the maxillary slices (SNR=12.6, 37.6, 97.0; CNR=13.2, 35.3, 88.5), while measurements in other regions showed an increase or decrease in different variables depending on the imaging protocol.

The Friedman test showed that the differences in SNRs or CNRs among anthropometric slices (paranasal sinus, maxilla, and mandible) for each imaging protocol were statistically significant (p=0.05). Among the anthropometric phantom slices, the lowest SNR (8.1-8.6) and CNR (8.0-8.7) values were calculated in paranasal slices, while the highest calculations were obtained in maxilla slices, except for the “Low Dose” protocol. In the “Low Dose” protocol, the highest SNR (19.1) and CNR (19.3) values were calculated in mandible slices.

Spearman’s ρ revealed that the pairwise relationships between the QA phantom and the maxillary (p=0.01), and mandibular (p=0.05) slices were statistically significant for both the SNR and CNR values, while it was found not statistically significant for QA phantom and the paranasal slices (p=0.17). Kendall’s τ revealed that only the pairwise relationship between the QA phantom and maxillary (p=0.02) slices was statistically significant, however, correlations between the QA phantom and paranasal sinus (p=0.13) or mandibular (p=0.06) slices did not reach statistical significance threshold. Among the anthropometric phantom slices, the maxilla region showed the greatest change by imaging protocol (p<0.05), while the relationships between the maxillary slices (SNR: 12.6 - 97, CNR: 13.2 - 88.5) and QA phantom (SNR: 16.2 - 23.3, CNR: 15.5 - 20.6) were found to be statistically significant (p<0.05) (Table 1).

Table 1. Signal-to-noise (SNR) and contrast-to-noise ratios (CNR) calculated using three slices of the anthropometric phantom (paranasal sinus, maxilla, and mandible) and a single slice of the quality assurance (QA) phantom.

Sample Image Slice	Signal-to-Noise Ratio				Contrast-to-Noise Ratio				p ¹	
	Low Dose	Regular	Best Quality	p ²	Low Dose	Regular	Best Quality	p ²		
Anthropometric Phantom	Paranasal Sinus	8.1	8.6	8.5	0.37	8.0	8.6	8.7	0.37	0.028*
	Maxilla	12.6	37.6	97.0	0.37	13.2	35.3	88.5	0.37	0.028*
	Mandible	19.1	19.4	23.1	0.37	19.3	19.2	23.1	0.37	0.028*
	p ³	0.046*	0.046*	0.046*		0.046*	0.046*	0.046*		
Quality Assurance Phantom	Single	16.2	19.1	23.3	0.37	15.5	17.6	20.6	0.37	0.028*
	p ²	0.39	0.39	0.39	0.39	0.39	0.39	0.39		

p¹: Wilcoxon Signed Rank Test, p²: Kruskal-Wallis Test, p³: Friedman Test

DISCUSSION

In this study, an anthropometric phantom and a QA phantom were imaged with the CBCT system in three different protocols (Low Dose, Regular, and Best Quality), and a total of six volumetric data sets were acquired. Three axial slices (paranasal sinus, maxilla, and mandible) were sampled from the anthropometric phantom volume, while a single axial slice was taken from the QA phantom volume for each imaging protocol. In each slice, three ROIs representing bone and soft tissues were identified, and SNR and CNR values were calculated by combining the mean gray values.

According to the results of this experiment, the differences in slices of paranasal sinus, maxilla, mandible, and QA were found to be statistically insignificant, while the association between QA and maxilla slices was statistically significant. The relationship between the QA and mandible slices was statistically significant with Spearman's test. There was no relationship between QA and paranasal sinus slices. Results of this study support the suggestion that the SNR and CNR values calculated in CBCT imaging using anthropometric and QA phantoms may be considered similar, but testing whether anthropometric phantom measurements can completely replace the quality control phantom was beyond the scope of the present study. Each phantom type is designed for its own purpose, and outlier measurements can be considered a secondary finding.

A study evaluated the effective dose and image quality of horizontal CBCT in comparison with multislice spiral CT (MSCT) in scans of the head, cervical spine, ear, and dental arches, which used a head and neck Alderson-Rando® phantom for effective dose calculation, while a CATPHAN® 504 phantom (The Phantom Laboratory, New York, USA) for quantitative image quality assessment concluded that in ear and dental arch imaging, CBCT was preferable to MSCT due to its lower radiation dose, and MSCT should be recommended when a high contrast resolution is required.¹² Another study compared the effective dose and subjective image quality of temporomandibular joint examinations with a dental CBCT device, a MSCT device, and an anthropometric phantom. Four dentomaxillofacial radiologists assessed the image quality on a one to three scale,

and the dose is optimized based on the scores. The authors reported a 50% dose reduction when compared to the manufacturer's standards.¹³ In the present study, radiation dose was not calculated and only CBCT was used as the imaging technique.

Ten clinically applied protocols were investigated in a study using the CS 9300 (CareStream SM 749, Rochester, NY) CBCT scanner and the CBCT QAT phantom (Kodak, Rochester, NY). The authors reported that increasing kVp results in an increase in both SNR and CNR values.¹⁴

In the present study, an increase in SNR and CNR values with increasing dose was observed in QA phantom and maxillary slices, while for paranasal and mandibular slices, minimal decreases in image quality test values were noted with increasing dose in specific conditions.

In a study evaluating image quality, segmentation accuracy, and radiation dose of four CBCT scanners, Accuitomo 3D (Morita, Kyoto, Japan), MercuRay (Medico Technology Corporation, Kashiwa, Japan), NewTom 3G (Quantive Radiology, Verona, Italy), i-CAT (Imaging Sciences International, Hatfield, PA), and a Sensation 16 (Siemens, Erlangen, Germany) multidetector computed tomography (MDCT) device, a skull phantom (scanned by laser scanner), and contrast phantom (PMMA cylinder with cylindrical inserts of air, bone, and PMMA) was used. The authors reported that the lowest radiation dose was found for the Accuitomo 3D, with the smallest image area, and the best segmentation accuracy was found for the i-CAT.¹⁵ In that study, CBCT volumes obtained with different devices were analyzed for patient dose and 3D model generation, whereas in our study, different acquisition modes on a single device were utilized.

Another study investigated the effect of mAs reduction on clinical and technical image quality using a polymethyl methacrylate (PMMA) phantom and an anthropometric skull. The PMMA phantom was used to calculate the CNR, and eight axial and one coronal slice of skull phantom was scored by six dentomaxillofacial radiologists. The authors reported that the reduction in mAs often resulted in image quality remaining within acceptable limits.¹⁶ In the relevant study, anthropometric phantom and image quality assessments were conducted by subjective scoring

of observers and QA phantom was used for quantitative tests. In the present study, both phantom types were used only for image quality estimation.

In a study, the impact of different exposure parameters on image quality and radiation dose CT system was evaluated using cadaver forearm and an orthopedic cone-beam device. Subjective and objective image quality tests were performed, and the authors reported a dose reduction of 18.9% compared to the manufacturer's recommended protocol.¹⁷ Another study investigated the image quality at different cone-beam computed tomography settings and three FOVs. CBCT scans of a cadaver head and a dry skull were scored by at least 30 observers, and results showed that the images taken at lower mA settings showed good diagnostic quality.¹⁸ While the cadaveric arm and head used in that study can be considered superior to QA or anthropometric phantoms in simulating the real patient, there are limitations regarding the repeatability and reproducibility of the imaging performed, in addition to supply and storage limitations. The two phantom types used in our study are both static and offer advantages in terms of mass production, transportation, and storage conditions.

There are numerous studies evaluating different CBCT protocols for image quality. High-dose protocols have been found to improve spatial resolution, reduce artifacts, and enhance SNR. However, despite their superior image quality, high-dose protocols are not recommended due to the associated increase in effective dose. On the other hand, low-dose protocols, when combined with noise reduction filters, are considered more beneficial for clinical applications, balancing image quality with radiation safety.^{14,19,20}

QA phantoms, anthropometric phantoms, and cadaveric specimens are used in studies with image quality elements in CBCT. While the primary role of QA phantoms is for image quality testing, dental CBCT devices are reported to require specialized QA phantoms due to their unique characteristics. However, it can be argued that an anthropometric phantom or cadaveric specimen is superior to a QA phantom in simulating a real patient. Indeed, cadaveric specimens have limitations in terms of storage and transportation. In contrast to previous anthropo-

metric phantom and image quality testing studies, quantitative calculations were made in the present study, not subjective observer scores. According to the results of this study, within its limitations, the measurements performed on anthropometric phantom slices were, to some extent, similar to the image quality tests performed with the QA phantom. However, our findings were not sufficient to fully support the use of one type of phantom over another, and future studies can be considered for more information on the subject.

One of the limitations of this study is that the imaging was performed with a single device. Moreover, this study could be improved with different FOV and other parameters. In this study, the largest FOV (13x10 cm) that does not require a vertical stitch procedure was selected. Among the slices corresponding to the three vertical heights in the anthropometric phantom, the strongest correlation with the QA phantom was found in the maxilla slice located in the center. However, the paranasal sinus and mandible regions were selected from slices closer to the upper and lower boundaries of the FOV area. Although the device supports a height of 16 cm, this is only possible with a vertical stitching procedure. In imaging with the largest FOV (13x16 cm), such centers in the vertical height will be two, not a single one, and the upper part of the lower volume and the lower part of the upper volume will overlap with one another. The vertical stitch procedure was not required for the FOV size selected in our study, and future studies can be performed with a different FOV size that require such procedure. The QA phantom utilized in this study is not the recommended QA phantom to be used in this CBCT system, and the difference in size can be considered as another limitation of this study. The relevant QA phantom is designed for use with devices that support a larger FOV, and its positioning within the device was suboptimal. This may have an impact on the results.²¹ Future studies with different QA and anthropometric phantoms that support various dental CBCT devices may be beneficial.

CONCLUSION

The development of new phantoms may address the limitations of QA phantoms, which may not meet all the criteria for assessing the quality of CBCT images. It is essential for clinicians and radiologists to

have access to cost-effective, user-friendly phantoms suited for both small and large FOVs. Results of this research support that the measurements with anthropometric phantom slices may be worth studying/considering. However, the results should be interpreted with caution. The impact of changing the imaging mode (Low Dose, Regular and Best Quality) in developing quantitative machine learning tools or additive manufacturing applications could be the subject of future research.

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Original Research Article

The Effects of Nutritional Habits on Oral Health: A Survey Study

Beslenme Alışkanlıklarının Ağız Sağlığı Üzerindeki Etkileri: Anket Çalışması

Eda İzgi¹ , Nur Mollaoğlu² 

ABSTRACT

Aim: To evaluate nutritional status and oral health awareness in a sample of Turkish population and to determine the relationship between nutritional status, oral health, and oral hygiene habits.

Materials and Method: This study was a cross-sectional survey. Using the World Health Organization's Oral Health Assessment Questionnaire, 16 questions were asked about demographic characteristics, oral hygiene practices, daily dietary habits, smoking and alcohol consumption, and current oral health. Following intraoral examinations of the volunteers, any caries, and, filled and missing teeth were recorded. The relationship between potential variables and oral health was evaluated using descriptive statistics.

Results: A total of 200 participants were included in the study. There was no significant difference in the distribution of caries, filled and missing teeth scores, and Decayed-Missing-Filled-Teeth (DMF-T) index between the genders. It was, however, found that female participants brushed their teeth more frequently and flossed more frequently. Taking time off from work due to oral health problems was more common in female participants than males. There was a significant increase in the frequency of missing teeth and caries in participants who consumed sweet foods and beverages.

Conclusion: Results displayed that female participants pay more attention to oral hygiene practices than male participants. A correlation was found between the frequency of consumption of fermentable sugar-containing foods and the DMF-T index. It was concluded that healthy eating habits play a significant role in maintaining oral health and preventing dental diseases.

Keywords: DMF-T; Feeding behavior; Oral health; Oral hygiene; Turkish patients

ÖZET

Amaç: Bir grup Türk popülasyonunda beslenme düzeyini ve ağız sağlığı farkındalığını değerlendirerek, beslenme durumu ve ağız sağlığı ile oral hijyen alışkanlıkları arasındaki ilişkiyi belirlemektir.

Gereç ve Yöntem: Bu çalışma kesitsel bir anket çalışmasıdır. Dünya Sağlık Örgütü'nün Ağız Sağlığı Değerlendirme anketi kullanılarak, demografik veriler, oral hijyen uygulamaları, günlük beslenme alışkanlıkları, sigara ve alkol tüketimi ile mevcut ağız sağlığı hakkında 16 soru yöneltilmiştir. Gönüllülerin intraoral muayenesini takiben çürük, dolgu ve eksik dişler kayıt altına alınmıştır. Potansiyel değişkenler ile ağız sağlığı arasındaki ilişki tanımlayıcı istatistikler eşliğinde değerlendirilmiştir.

Bulgular: Çalışmaya toplam 200 katılımcı dahil edilmiştir. Farklı cinsiyet gruplarında çürük, dolgu, eksik diş skoru ve DMF-T indeksi dağılımları açısından anlamlı bir fark bulunamamıştır. Ancak, kadın katılımcıların erkeklere oranla daha sık dişlerini temizlemekte ve diş ipi kullanmakta olduğu saptanmakla birlikte; ağız sağlığı problemleri nedeniyle işten izin alma durumunun kadın katılımcılarda erkeklere nazaran daha fazla olduğu görülmüştür. Cinsiyetten bağımsız olarak şekerli yiyecek ve içecek tüketen katılımcılar arasında ise sıklık derecesine göre çürük diş skorunda ve eksik diş sayısında anlamlı bir artış olduğu tespit edilmiştir.

Sonuç: Kadınlar erkeklere oranla oral hijyen uygulamalarına daha fazla özen göstermektedir. Fermente olabilen şeker içeren gıdaların tüketim sıklığı ile DMF-T indeksi arasında bir korelasyon bulunmaktadır. Sağlıklı beslenme alışkanlıklarının ağız sağlığını korumada ve diş hastalıklarını önlemede kritik bir rol oynadığı anlamlı olarak saptanmış bulunmaktadır.

Anahtar Kelimeler: Ağız hijyeni; Ağız sağlığı; Beslenme davranışı; DMF-T; Türk hastalar

Makale gönderiliş tarihi: 28.11.2024; Yayına kabul tarihi: 27.03.2025

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INTRODUCTION

Oral diseases are among the most common non-contagious diseases as a serious public health problem in developed and developing countries.¹ According to the latest Global Burden of Disease report (2019), oral diseases, including dental caries, periodontal disease, tooth loss, and oral mucosal lesions, affect more than 44.5% of the global population.² The impairments caused by oral diseases can directly lead to pain, sepsis, prolonged schooling in childhood, reduced work productivity in adults, and reduced overall quality of life.³ Although oral diseases are largely preventable, they continue to be a neglected problem.¹

Oral health is an integral part of general health and supports individuals' ability to engage with society and realize their potential. Beyond basic life functions such as eating, breathing, and speaking, oral health has psychosocial impacts, contributing to self-confidence, well-being, socialization, and pain-free living, thus holding a significant place in human life.⁵ It directly affects nutrition and general health status and is similarly influenced by them¹. The World Health Organization (WHO) lists oral health as one of the top 10 standards for healthcare problem and suggests that oral diseases are a key factor in determining quality of life.⁶ Demographic, economic, and educational changes also impact dental caries, periodontal disease, and diseases like oral cancer.⁷ Therefore, the severity of oral diseases varies by region, ethnicity, age, and gender. The rising prevalence of oral diseases in many undeveloped and developing countries remains a concern.²

Nutrition is a critical part of health and development. Better nutrition is associated with improved infant, child, and maternal health, stronger immune systems, safer pregnancies and births, lower risk of non-contagious diseases (such as diabetes and cardiovascular disease), and longer life spans.³ Nutrition, which is the foundation of human development, requires a balanced and adequate intake of carbohydrates, proteins, fats, vitamins, minerals, and water throughout life. There is a multifactorial relationship directly linked to nutrition and oral health. Inadequate nutrition can directly affect growth and development, as well as cause various disorders on all orofacial components. These disorders can be listed as dental caries, various periodontal diseases

(gingivitis, periodontitis), and oral mucosal diseases (aphthous stomatitis, glossitis, cheilitis, and angular stomatitis). On the other hand, poor oral health conditions, such as missing teeth, acute periapical infections, and oral mucosal diseases, may negatively affect individuals' daily diets.⁴

Understanding the role of nutrition in overall health is crucial. Therefore, determining and managing oral health conditions and nutritional issues are important to improve the health and quality of life of affected individuals. This study was designed to clarify the factors influencing the impact of nutritional habits on oral health in a sample of Turkish patients. The aim of the study was to evaluate the nutritional status and oral health awareness of the group of Turkish patients and determine the relationship between nutritional status, oral health, and oral hygiene habits.

MATERIALS AND METHOD

This study was designed as a cross-sectional survey. Volunteers recruited from patients who applied to Kütahya Health Sciences University University Oral and Dental Health Application and Research Center due to dental complaints in June and July 2024. Volunteers who agreed to participate in the study were asked to answer the survey questions. Volunteers over 18 years of age who had no medical condition that would prevent oral examination were included in the study. Volunteers with absorption and digestive disorders were excluded from the study.

The WHO Oral Health Assessment Questionnaire was used for this study.⁵ Through this survey, 16 questions about demographic data (age, gender, rural/urban life, education level, occupation, average monthly income level), oral hygiene habits, daily nutrition habits, smoking and alcohol consumption, and current oral status were asked. A full oral examination was conducted for all volunteers who completed the survey, and a record was made with a table showing decayed, filled, and missing teeth to calculate the Decayed-Missing-Filled-Teeth (DMF-T) index. Teeth with both fillings and decay were considered decayed, while teeth with crowns were counted as filled. For each volunteer, the DMF-T score was calculated as the total number of decayed, filled, and missing teeth, and the mean DMF-T for the study group was calculated as the Total DMF-T / examined number of volunteers. The survey form given

to the participants was filled face-to-face in the Oral and Maxillofacial Surgery clinic without any time limitation. To ensure data quality before the survey, all participants were informed that they should answer all the questions completely and that each question should have only one answer. To ensure participant confidentiality, volunteers' identity was not included in the survey form.

Data Analysis

Following the completion of the survey forms, the collected data was transferred to the computer environment and the answers of the participants to each question were shown with their percentages in tables. Some descriptive statistics regarding the participants' dietary habits (e.g. frequency of consumption of certain foods and beverages) were presented through graphs. The analysis of the relationships between dietary patterns and oral health outcomes (such as the frequency of decay, filled, or missing teeth) was presented through tables. Potential confounding variables (e.g. oral hygiene practices, socioeconomic status) and their effects on the relationship between nutrition and oral health were assessed.

Statistical Analysis

The proportions were assessed for statistically significant differences by the Chi-squared test. In RxC contingency tables for more than 10% cells with expected values <5 , we used the result of Fisher's exact test instead of chi-squared. If all the observed values were >25 and expected values >5 , Chi-squared test result was used.

Ethical Approval

This study was approved by the Kütahya Health Sciences University University Non-Interventional Clinical Research Ethics Committee (Decision date: 17/05/2024, Approval no: 2024/07-12).

Informed Consent Form

The volunteers were informed about the study design and objectives by the researchers. Volunteers were not provided with any incentive to participate in the study, and they were informed about their right to withdraw at any time without any pressure. A signed informed consent form was obtained from the vol-

unteers who were informed and participated in the study voluntarily.

RESULTS

Demographic Characteristics of Volunteers

A total of 225 volunteers participated in the study of which 25 were excluded due to missing data. The mean age of the participants was 36.5 ± 14.3 years. Demographic characteristics of the participants are shown in Table 1 as frequencies and percentages. The results revealed that the frequency of smoking ($p < 0.001$) and alcohol use ($p = 0.002$) was higher among male than female patients.

Participants' oral hygiene habits and problems they experienced

Table 2 presents the statistical analysis findings of oral health practices of the volunteers. A significant difference was found between the distribution of the frequency of the participants' brushing their teeth in gender groups ($p < 0.001$). Female participants cleaned their teeth more frequently than male participants (Figure 1). Awareness of whether toothpastes contain fluoride displayed no statistically significant difference between gender groups ($p = 0.65$). Apart from flossing, there was no statistically significant difference in the distribution of agents used for tooth cleaning (e.g., toothbrush, toothpick, miswak, etc.) between gender groups ($p > 0.05$). There was a difference in the use of dental floss between genders ($p = 0.005$); females used floss more frequently than males. The distribution of agents used by participants for cleaning their teeth is shown in Figure 2. Of the participants, 98.5% ($n = 197$) used toothpaste for cleaning their teeth, but 67% ($n = 134$) did not know whether their toothpaste contained fluoride. Only 26.5% ($n = 53$) of the participants used toothpaste that contained fluoride. In terms of recent dental visits, 42% ($n = 84$) of the participants reported that their last dental visit was within the past 6 months, and 24.5% ($n = 49$) reported visiting within the past 6 to 12 months. The primary reason for visiting the dentist was for pain or discomfort in teeth, gums, or mouth (60%, $n = 121$), followed by visits for treatment or follow-up (31%, $n = 62$). Responses to questions assessing how participants perceived their oral and gum health showed no statistically significant difference

between genders ($p=0.57$ and $p=0.46$). However, a significant difference was found between gender groups regarding the response to the question "Have you experienced any pain or discomfort in your teeth and/or mouth in the last year?" ($p=0.03$). Females reported experiencing dental problems more frequently than males in the past year. Despite this, the association between the frequency of dental visits and the DMF-T score did not reach statistical significance in this sample ($p=0.08$).

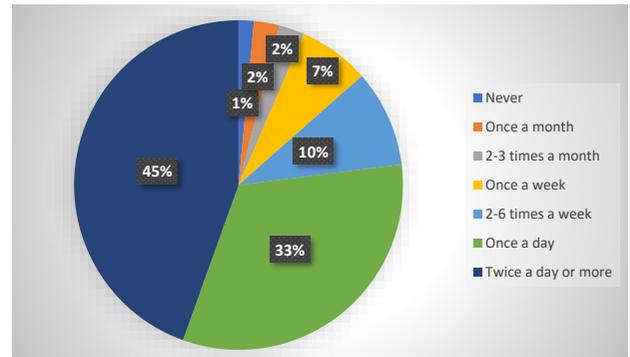


Figure 1. Participants' frequency of tooth brushing

Table 1. Sociodemographic characteristics of the participants

Demographic characteristics	Answers	Number	Percentage
Gender	Female	118	59
	Male	82	41
Marital Status	Married	80	40
	Single	115	57.5
	Widow	5	2.5
Region of residence	Province	180	90
	District	18	9
	Quarter	1	0.5
	Village	1	0.5
Education level	Illiterate	4	2
	Literate	33	16.5
	Primary School	20	10
	Secondary School	50	25
	High School	86	43
	University	7	3.5
	Master's/Doctorate	0	0
Occupation	Housewife	48	24
	Employee	33	16.5
	Civil Servant	32	16
	Tradesman	4	2
	Self-employed	17	8.5
	Retired	15	7.5
	Unemployed	11	5.5
	Student	40	20
Monthly income	Low income	64	32
	Low-middle income	15	7.5
	Middle income	27	13.5
	High-middle income	22	11
	High income	20	10
	Very high income	52	26
Smoking	Yes	56	28
	No	125	62.5
	Quit	19	9.5
Alcohol use	Yes	37	18.5
	No	163	81.5

Table 2. Oral health practices and oral health status by gender.

Oral health practices	Answers	Total		Female		Male		p *	
		n	%	n	%	n	%		
Frequency of brushing	Never	3	1.5	0	0	3	1.5	p< 0.001	
	Once a month	5	2.5	0	0	5	2.5		
	2-3 times a month	5	2.5	2	1	3	1.5		
	Once a week	14	7	9	4.5	5	2.5		
	2-6 times a week	19	9.5	10	5	9	4.5		
	Once a day	65	32.5	33	16.5	32	16		
	Twice a day or more	89	44.5	64	32	25	12.5		
Agents used for tooth brushing	Toothbrush	199	99.5	118	59	81	40.5	p>0.05	
	Wooden toothpick	47	23.5	24	12	23	11.5		
	Plastic toothpick	3	1.5	0	0	3	1.5		
	Dental floss*	45	22.5	35	17.5	10	5		
	Black pencil	1	0.5	0	0	1	0.5		
	Miswak	11	5.5	5	2.5	6	3		
Use of fluoride toothpaste	Yes	53	26.5	34	17	19	9.5	p= 0.65	
	No	13	6.5	7	3.5	6	3		
	I don't know	134	67	77	38.5	57	28.5		
Defining teeth and gum condition	<i>Teeth condition</i>								p= 0.57
	Excellent	1	0.5	1	0.5	0	0		
	Very good	5	2.5	2	1	3	1.5		
	Good	34	17	21	10.5	13	6.5		
	Average	88	44	52	26	36	18		
	Bad	38	19	24	12	14	7		
	Very bad	26	13	12	6	14	7		
	I don't know	8	4	6	3	2	1		
	<i>Gum condition</i>								p= 0.46
	Excellent	2	1	2	1	0	0		
	Very good	7	3.5	4	2	3	1.5		
	Good	43	21.5	29	14.5	14	7		
	Average	72	36	38	19	34	17		
	Bad	47	23.5	30	15	17	8.5		
Very bad	15	7.5	8	4	7	3.5			
I don't know	14	7	7	3.5	7	3.5			
Use of removable denture	Partial denture	11	5.5	7	3.5	4	2	*p=0.67	
	Lower total denture	3	1.5	2	1	1	0.5		
	Upper total denture	9	4.5	5	2.5	4	2		
Any pain/discomfort in your teeth and/or mouth in the last year?	Yes	154	77	97	48.5	57	28.5	p= 0.032	
	No	44	22	21	10.5	23	11.5		
	I don't know	2	1	0	0	2	1		

*p values are for comparison of responses by male and female participants in RxC tables as a single omnibus test.

Table 3. Frequency of dental or oral issues faced in the past year, according to gender.

Frequency of problems experienced in the last year	Total		Female		Male		p
	n	%	n	%	n	%	
<i>Difficulty in biting food</i>							p= 0.35
Very often	24	12	12	6	12	6	
Often	25	12.5	18	9	7	3.5	
Sometimes	56	28	35	17.5	21	10.5	
No	95	47.5	53	26.5	42	21	
<i>Difficulty chewing food</i>							p= 0.083
Very often	23	11.5	10	5	13	6.5	
Often	36	18	27	13.5	9	4.5	
Sometimes	43	21.5	26	13	17	8.5	
No	98	49	55	27.5	43	21.5	
<i>Difficulty in speaking/ pronouncing words</i>							p= 0.97
Very often	6	3	3	1.5	3	1.5	
Often	18	9	11	5.5	7	3.5	
Sometimes	22	11	12	6	10	5	
No	152	76	91	45.5	61	30.5	
I don't know	2	1	1	0.5	1	0.5	
<i>Dry mouth</i>							p= 0.26
Very often	5	2.5	3	1.5	2	1	
Often	14	7	11	5.5	3	1.5	
Sometimes	54	27	27	13.5	27	13.5	
No	124	62	76	38	48	24	
I don't know	3	1.5	1	0.5	2	1	
<i>Embarrassment of the appearance of teeth</i>							p= 0.091
Very often	24	12	13	6.5	11	5.5	
Often	33	16.5	22	11	11	5.5	
Sometimes	25	12.5	9	4.5	16	8	
No	1	0.5	1	0.5	0	0	
I don't know	117	58.5	73	36.5	44	22	
<i>Feeling nervous due to dental or oral problems</i>							p= 0.56
Very often	22	11	14	7	8	4	
Often	26	13	16	8	10	5	
Sometimes	51	25.5	27	13.5	24	12	
No	100	50	61	30.5	39	19.5	
I don't know	1	0.5	0	0	1	0.5	
<i>Avoiding smiling due to teeth</i>							p= 0.40
Very often	25	12.5	14	7	11	5.5	
Often	26	13	17	8.5	9	4.5	
Sometimes	25	12.5	11	5.5	14	7	
No	123	61.5	75	37.5	48	24	
I don't know	1	0.5	1	0.5	0	0	
<i>Frequent interruption of sleep</i>							p= 0.52
Very often	7	3.5	6	3	1	0.5	
Often	18	9	12	6	6	3	
Sometimes	33	16.5	18	9	15	7.5	
No	140	70	81	40.5	59	29.5	
I don't know	2	1	1	0.5	1	0.5	
<i>Taking time off from work*</i>							*p= 0.036
Very often	3	1.5	0	0	3	1.5	
Often	6	3	4	2	2	1	
Sometimes	27	13.5	11	5.5	16	8	
No	162	81	102	51	60	30	
I don't know	2	1	1	0.5	1	0.5	
<i>Difficulty in performing general activities</i>							p= 0.48
Very often	14	7	7	3.5	7	3.5	
Often	23	11.5	13	6.5	10	5	
Sometimes	162	81	98	49	64	32	
No	1	0.5	0	0	1	0.5	
<i>Decreased tolerance for people around</i>							p= 0.54
Very often	2	1	1	0.5	1	0.5	
Often	16	8	8	4	8	4	
Sometimes	21	10.5	11	5.5	10	5	
No	160	80	98	49	62	31	
I don't know	1	0.5	0	0	1	0.5	
<i>Decrease in willingness to participate in social activities</i>							p= 0.33
Very often	5	2.5	1	0.5	4	2	
Often	13	6.5	9	4.5	4	2	
Sometimes	18	9	9	4.5	9	4.5	
No	162	81	98	49	64	32	
I don't know	2	1	1	0.5	1	0.5	

* p<0.05, Fisher's Exact Test

Table 3 presents the statistical findings on issues experienced within the last year due to conditions of teeth or mouth in the study sample. Participants were questioned about the presence and frequency of issues such as difficulty in biting or chewing food, difficulty in talking/pronouncing words, dry mouth, feeling embarrassed by the appearance of teeth, feeling tense due to oral discomfort, sleep interruptions, difficulty in general activities, reduced tolerance towards others, and decreased desire for social interactions. No statistically significant relationship was found between these variables and gender groups. However, the frequency of taking time off work due to oral problems was significantly higher among female participants than male participants ($p=0.036$).

Analysis of answers regarding nutritional habits

The distribution of the frequency of consuming the specified foods regarding nutritional habits is shown in Figure 3. No statistically significant difference was found in the distributions of fresh fruit, biscuits, cakes, sweet pies, buns, jam/honey, sugary gum, sugary drinks, and sugary tea/coffee consumption between gender groups ($p>0.05$). There was no difference between the frequency of fresh fruit consumption and the distribution of decayed teeth ($p=0.19$), filled teeth ($p=0.37$), missing teeth ($p=0.48$) scores and DMF-T

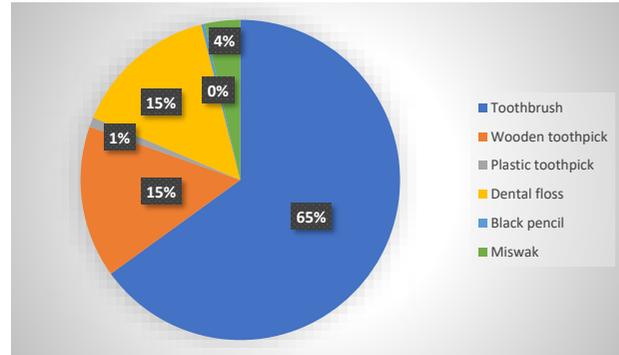


Figure 2. Distribution of the substances used by the participants for teeth cleaning [It is strange to see to see a 9% value in the pie chart and it is not possible to work out which category it refers to. It is best to remove that category from the list and not to show a 0% value in the pie chart. Whichever category it is, it can be mentioned in the legend.]

index ($p=0.82$). There was a significant relationship between the consumption of biscuits, cakes, and cream cakes and decayed and missing teeth scores. ($p=0.021$). When the frequency of consumption was analyzed, a statistically significant association was found between decayed teeth scores for those consuming certain items a few times a month and those consuming them several times a day ($p=0.001$). A significant association was also observed in missing teeth scores between those consuming these items

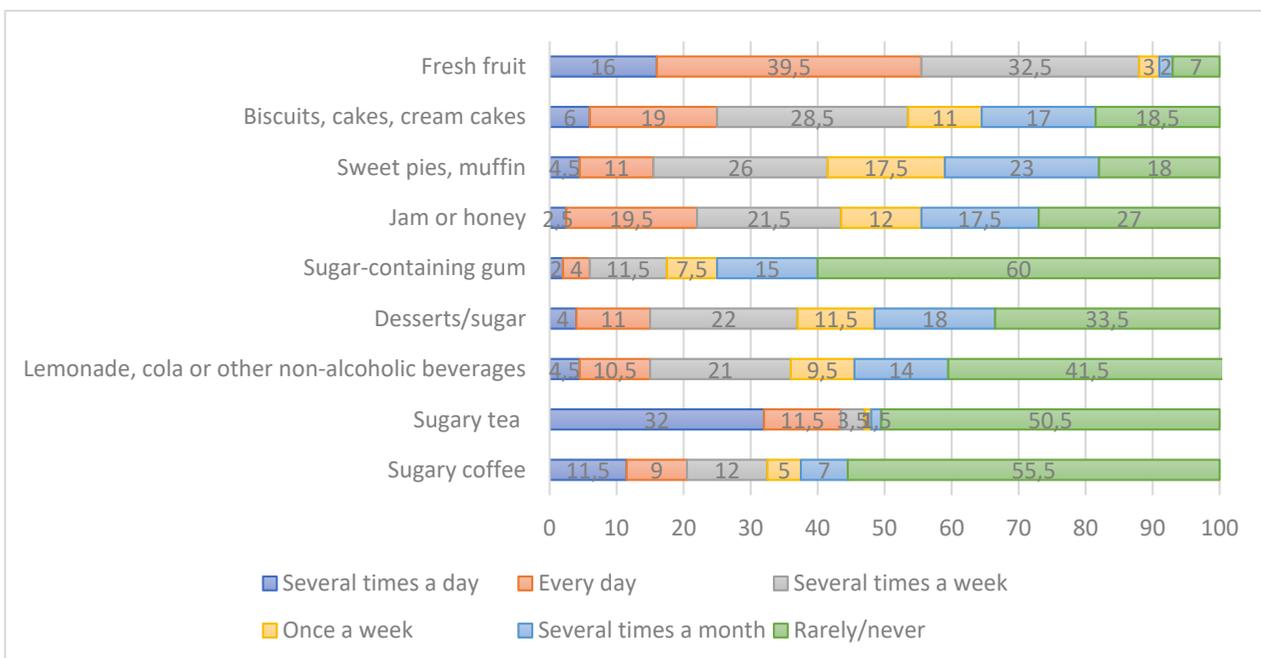


Figure 3. Percentage Distribution of Specified Food Consumption by Dietary Habits.

a few times a week and those who never consumed them ($p=0.001$). The DMF-T index was significantly higher among daily consumers compared to those who never consumed these items ($p=0.001$). However, no significant difference was found between the frequency of sweet pie or pastry consumption and scores for decayed ($p=0.18$), filled ($p=0.63$), or missing teeth ($p=0.38$). Additionally, the frequency of jam or honey consumption was not significantly associated with scores for decayed ($p=0.91$), filled ($p=0.97$), or missing teeth ($p=0.23$). Similarly, no significant difference was observed between the frequency of sugar-containing gum consumption and decays ($p=0.65$), filled ($p=0.31$), or missing teeth scores ($p=0.07$). The frequency of sweets or sugar consumption did not show a significant difference for decayed ($p=0.88$) or filled ($p=0.89$) teeth scores; however, there was a significant difference for missing teeth ($p=0.012$) and the DMF-T index ($p=0.023$). The DMF-T index was statistically significantly higher in groups that consumed sweets or sugar a few times a week compared to those who rarely or never consumed them ($p=0.014$).

No significant difference was found between the frequency of lemonade, cola or other soft drinks consumption and the number of decayed teeth although it was close to significance level ($p=0.056$), filled teeth ($p=0.590$) and DMF-T index ($p=0.361$); however, a significant relationship was detected with missing teeth score ($p=0.018$). The number of missing teeth was found to be significantly higher in participants who consumed lemonade, cola, or other soft drinks every day compared to the group who rarely/never consumed them ($p=0.038$). No significant difference was found between the frequency of sweetened tea consumption and the number of decayed ($p=0.52$), filled ($p=0.67$) or missing teeth ($p=0.198$), and the DMF-T index ($p=0.377$). No significant difference was found between the frequency of sweetened coffee consumption and the number of filled ($p=0.60$) or missing ($p=0.84$) teeth, as well as the DMF-T index ($p=0.73$). However, those who consumed sweetened coffee several times a day had a statistically significantly higher number of decayed teeth compared to those who consumed it several times a month ($p=0.048$).

Analysis of answers regarding oral health

The average number of decayed teeth was 3.2 ± 3.2 , the average number of filled teeth was 3.7 ± 3.6 , the average number of missing teeth was 6.4 ± 7.3 and the average DMF-T index value was 13.2 ± 7.5 . No significant difference was found in terms of decayed, filled, and missing teeth scores and the DMF-T index distributions in gender groups ($p>0.05$). No statistically significant relationship was found between cigarette consumption and DMF-T index distributions ($p=0.25$). However, there was a statistically significant difference in the distribution of the DMF-T index between alcohol users and non-users ($p=0.018$). When the answers given to the question about the frequency of brushing the teeth were examined, a significant difference was found between the DMF-T indices of females and males ($p=0.009$). There was a significant relationship between oral problems experienced in the last year and the DMF-T index distributions ($p<0.001$). There was also a significant difference in the DMF-T index distributions between the groups reporting the most common complaint of difficulty in chewing foods as 'sometimes' and 'very often' ($p=0.027$).

DISCUSSION

In this survey, the nutritional habits, oral hygiene practices, and their potential relationship with the oral and dental health of adult patients who applied to the oral and maxillofacial surgery clinic were evaluated. We observed that regardless of the demographic characteristics, when sugar and sugary foods were predominant ingredients of the diet, it did negatively affect dental health. Studies evaluating the effects of eating habits on oral health have been conducted on samples in different populations. A study carried out on a large sample in Saudi Arabia evaluated the awareness of participants about the effect of diet on dental caries and showed that more than half of the participants knew about the relationship between diet and dental caries.⁶ In a study conducted in India where the effects of nutrition on oral and dental health were evaluated among students of the nutrition and dietetics department, it was emphasized that the participants' awareness and knowledge on the subject were insufficient. The lack of knowledge about the effects of nutrition on oral and dental health has been pointed out as a ma-

for problem even among healthcare professionals.⁷ A systematic review including 70 articles evaluating the knowledge of oral and dental health workers and dietitians also showed that health workers had insufficient knowledge about the effects of nutrition on oral and dental health.⁸ In another study conducted in Nigeria, it was emphasized that there is a need for dietitians and health professionals to improve ways in which they can help to prevent poor oral health resulting from malnutrition and poor eating habits.⁹

In our study sample, no statistically significant difference was found in the answers regarding eating habits between gender groups ($p>0.05$). It was, however, found that female participants paid more attention to oral hygiene practices than male participants (Table 2). Considering the data obtained in our study, females were exposed to more dental problems in the last year and had to take leave from work due to oral health problem (Table 3). According to the literature, women have higher nutritional awareness compared to men.^{10,11} The fact that women are more knowledgeable about nutrition and have better oral hygiene practices compared to men suggests that women may be more concerned about nutrition and oral health than men.¹² However, this situation may vary in different countries. For instance, in Malaysia and Palestine, there was no statistically significant difference between males and females in terms of nutritional knowledge and awareness levels regarding the effects of nutritional knowledge on oral / dental health.^{11,13} In another study carried out among parents in Italy, it was demonstrated that there were no significant differences in mentally and behaviorally among parents regarding their own and children's oral hygiene.¹⁴

Dental caries is one of the most common non-contagious diseases and remains a significant public health concern. Although it has a multifactorial etiology, increased sugar consumption is directly related to the risk of caries.¹⁵ Dental caries is a dynamic process involving susceptible tooth surfaces, cariogenic bacteria primarily *Streptococcus mutans* and a fermentable carbohydrate source. Sucrose is the most common dietary sugar and is considered the most cariogenic carbohydrate. Frequent consumption of carbohydrates in simple sugar form increases the risk of caries.¹⁶ Fermentable sugars are the primary energy source for cariogenic bacteria and, over time,

cause the pH on tooth surfaces to drop, leading to demineralization of the hard tissue of teeth. Therefore, individuals with a diet rich in mono- and disaccharides have a high risk of caries. Sticky foods such as chocolate, cookies, and cakes tend to lodge in tooth pits and fissures, thereby increasing the risk of caries. Additionally, liquid sugars in sugary tea/coffee, fruit juices, and sugary acidic drinks may have a more pronounced effect on the risk of caries.¹⁶ With recent lifestyle changes, the consumption of sugar-sweetened beverages has been on the rise.¹⁶ In this cross-sectional study conducted on a sample of Turkish patients, no significant difference was found in the frequency of sugar and sweetened product consumption between gender groups. However, a relationship was found between current sugar consumption habits and the DMF-T index, which could contribute to understanding the role of sugar intake in caries development. In women living in low-income areas of Texas, USA, the correlation between nutrition knowledge, socioeconomic factors, and caries development was evaluated using the Dental Nutrition Knowledge Competency (DNKC) scale to assess knowledge and the DMF-T index to evaluate caries experience. Results indicated that knowledge about the impact of diet on caries development was limited among participants. It also demonstrated a relationship between demographic variables and both nutrition knowledge and dental caries. It was emphasized that public health interventions aimed at reducing caries, especially in low-income populations, should include strategies to improve nutrition knowledge and promote behavioral change.¹⁷

Nutritional knowledge can directly influence an individual's oral health and, through parents, also affect their children's oral health. In a related study evaluating the knowledge and awareness about proper eating habits that could be passed down through generations, it was reported that Polish mothers lacked correct nutrition knowledge, adversely impacting their children's oral health.¹⁷ Another study showed that Jordanian adults had low levels of knowledge regarding periodontal disease, suggesting the need for more educational programs to raise awareness of oral health.¹⁷

The effects of alcohol and tobacco use on dental health are more complex. While alcohol's effect is generally considered weak, the association between

smoking and periodontal disease is more apparent. Similar to the study by Tanner *et al.*¹⁸, smoking was reported to be statistically significantly associated with high caries experience and increased gum bleeding. In contrast, alcohol consumption was not found to be related to caries or periodontal disease. In our study, while no statistically significant relationship was found between smoking and the DMF-T index, participant who has got high alcohol consumption had significantly higher scores of DMF-T index. The effects of alcohol and tobacco use on caries appear to be independent of socioeconomic status and geographical factors.

The DMF-T index is a scale widely adopted worldwide and frequently used in epidemiologic studies to assess oral and dental health status. This index identifies the number of decayed, treated, and missing teeth. In this study, a significant relationship was found between the frequency of brushing and the DMF-T index.¹⁹ In addition to chewing and speech difficulties, dry mouth and aesthetic concerns were significantly higher in individuals with higher DMF-T index. Particularly, those who frequently had trouble with chewing had a statistically significantly higher DMF-T index than those who sometimes had difficulty. In addition to fermentable sugar consumption and oral hygiene practices, age and gender also impact the DMF-T index. The DMF-T index ranges from 5 to 20, with a median value of 13, indicating that most individuals have a total of 13 missing, filled, or extracted teeth. The World Health Organization defines an acceptable dental health condition for adults aged 35-44 having DMF-T index between 9 and 13.9, while individuals having a DMF-T index above 13.9 considered as having high caries risk.²⁰ The median DMF-T index found in this study was within an acceptable range for adults, but it was close to a high caries risk level.

Certain cariogenic bacteria responsible for dental caries, such as *Streptococcus mutans* and *Lactobacillus*, are found in dental plaques.²¹ Brushing teeth is an effective mechanical method for removing dental plaque.²² Significant decreases in caries experience have been observed in many countries due to the widespread use of fluoride, resulting in substantial improvements in oral health.²³ Therefore, in the present study, regular brushing at least once a day was, as expected, associated with a low-

er DMF-T index compared to the irregular brushing group. In this sample, no significant difference was found between gender groups in terms of awareness of whether toothpastes contain fluoride (Table 2). In cases where DMF-T scores displayed no significant difference despite the higher sugar consumption and snack frequency, oral hygiene practice was explained as the dominant variable associated by the index. Individuals with optimal oral hygiene will have a lower DMF-T score.²⁴ Consequently, especially in individuals with a high DMF-T index, the positive interaction between dietary control for caries and oral hygiene practices should be well-explained, and individuals should be advised to reduce the frequency of fermentable carbohydrate intake and improve oral health-related habits.

This study did not collect data on participants' knowledge of the cariogenic potential of foods and beverages, the importance of dietary habits and recommended oral hygiene practices to maintain oral health. Furthermore, this study was limited to a single-center design with a specific time frame and a limited number of participants. Limitations of the study include subjective responses in the questionnaire and a limited sample group that could be overcome with more comprehensive and detailed studies. More comprehensive studies can be conducted on patients who have been informed about proper eating habits and oral health behaviors, and it may be more meaningful to examine their effects on the DMF-T index in the light of the information obtained from these studies.

CONCLUSION

This survey assessed the impact of dietary habits on oral health. The findings show that foods and beverages, especially those high in sugar, have a detrimental effect on oral health. The study reveals the critical role of healthy eating habits in maintaining oral health and preventing dental disease. These findings emphasize the importance of interventions focusing on diet and nutrition to improve oral health. Future studies with larger and more diverse sample groups may help us better understand this relationship. It is also crucial to develop strategies to improve dietary habits to maintain oral health. In conclusion, increasing individuals' awareness of the importance of personal dietary habits on oral health

will significantly contribute to the prevention of many oral health problems they may face in the future.

CONFLICT of INTEREST

Authors declare no conflicts of interest.

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Evaluation of the Bond Strength of Restorative Materials Applied to Base Materials and Pulp Capping Agents Using Different Techniques: An *In-Vitro* Study

Farklı Tekniklerle Uygulanan Restoratif Materyallerin Kaide Materyallerine ve Pulpa Kapaklama Ajanlarına Bağlanma Dayanımının Değerlendirilmesi: Bir İn-Vitro Çalışma

Merve Nezir¹ , Suat Özcan² 

ABSTRACT

Aim: To evaluate the shear bond strength (SBS) of restorative materials applied to base materials and pulp capping agents using different techniques *in-vitro*.

Materials and Method: A total of 80 acrylic blocks were obtained. Either Fuji II LC (FLC) or Biodentine (BD) was applied to the cavities opened in the center of the acrylic blocks. Thereafter, EverX Posterior (EXP) and Fuji IX (FIX) were used in a transparent plastic tube in accordance with the manufacturer's instructions in one group and placed after pre-heating in another group (n=10). Then the SBS test was performed. Three-way ANOVA test was used to evaluate the effect of base material/pulp capping agent, restorative material and application technique on SBS. One-way ANOVA test was used for comparisons of individual parameters between groups in application techniques. Tamhane's T2 test was used to determine the group causing the difference. Chi-square test, Fisher's Exact test, Fisher Freeman Halton Exact Chi-square test and Yates continuity correction were used to compare qualitative data. Significance was evaluated at $p<0.05$ level.

Results: After pre-heating, the SBS values of EXP to BD (6.4 ± 3.0 MPa) was significantly greater than that of FIX (1.2 ± 0.4 MPa) ($p<0.05$). When FLC material was used, the SBS values of EXP material were found to be higher than FIX material, regardless of the application technique.

Conclusion: When a base material containing resin is used, it can be concluded that using a composite resin restorative material is more appropriate in terms of obtaining higher SBS values.

Keywords: Biodentine; Fiber; Glass ionomer; Pre-heating; Shear bond strength

ÖZET

Amaç: Bu çalışmanın amacı, farklı tekniklerle uygulanan restoratif materyallerin kaide materyallerine ve pulpa kapaklama ajanlarına makaslama bağlanma dayanımının (SBS) *in-vitro* olarak değerlendirilmesidir.

Gereç ve Yöntem: Toplam 80 adet akrilik blok elde edildi. Akrilik blokların ortasına açılan kavitelere Fuji II LC (FLC) veya Biodentine (BD) uygulandı. Daha sonra, EverX Posterior (EXP) ve Fuji IX (FIX) şeffaf plastik bir tüp kullanılarak; bir grupta üretici firmanın talimatlarına uygun olarak, diğer grupta ise ön ısıtma uygulandıktan sonra yerleştirildi (n=10). Ardından SBS testi gerçekleştirildi. Kaide materyali/pulpa kapaklama ajanı, restoratif materyal ve uygulama tekniğinin bağlanma dayanımı üzerindeki etkisinin değerlendirilmesinde Üç-yollu ANOVA testi kullanıldı. Uygulama tekniklerinde ayrı ayrı parametrelerin gruplar arası karşılaştırılmalarında tek-yollu ANOVA testi kullanıldı. Farka neden olan grubun belirlenmesinde Tamhane's T2 testi kullanıldı. Niteliksel verilerin karşılaştırılmasında ise Ki-Kare testi, Fisher's Exact Ki-Kare testi, Fisher Freeman Halton Exact Ki-kare testi ve Yates düzeltmesi kullanıldı. Anlamlılık $p<0.05$ düzeyinde değerlendirildi.

Bulgular: Ön ısıtmadan sonra EXP'nin BD'ye (6.4 ± 3.0 MPa) olan SBS değerleri, FIX'in (1.2 ± 0.4 MPa) bağlanma dayanımından önemli ölçüde daha yüksekti ($p<0.05$). FLC malzemesi kullanıldığında, uygulama tekniğinden bağımsız olarak EXP malzemesinin SBS değerlerinin FIX malzemesine göre daha yüksek olduğu bulundu.

Sonuç: Resin içeren bir kaide materyali kullanıldığında, daha yüksek SBS değerleri elde etmek açısından kompozit rezin restoratif materyal kullanılmasının daha uygun olduğu sonucuna varılabilir.

Anahtar Kelimeler: Biodentine; Fiber; Cam iyonomer; Ön ısıtma; Makaslama bağlanma dayanımı

Makale gönderiliş tarihi: 29.08.2024; Yayına kabul tarihi: 25.03.2025

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INTRODUCTION

The mechanical and physical characteristics of composite resins can be enhanced through a variety of applications. Fiber-reinforced composite resins are an example of this application. Introduced for use as a reinforcing base for large restorations, these materials have material structure-strengthening properties such as inhibition of crack propagation owing to the incorporation of versatile short glass fibers into the resin matrix.¹ Fiber reinforcement technology has become an option for increasing the fracture strength and mechanical properties of particle-filled composite resins and has increased the use of composite resin materials for large restorations of stress-bearing posterior teeth. The aim of fiber reinforcement is to make the structurally affected tooth more durable internally and prevent fractures.²

Wilson and Kent³ introduced glass ionomer cements to dentistry in 1972. The particle size of the material varies by manufacturer, but sizes generally range from 20 µm for adhesive forms to 50 µm for restorative forms. High-viscosity glass ionomer cements have been developed to increase the wear resistance of conventional glass ionomer cements, strengthen their low mechanical properties, and increase their indications that are limited to class I and V restorations. These cements are considered as an alternative to amalgam and resin composites as permanent restorative materials. They are produced in the form of capsules because manual mixing and adjustment of the correct powder–liquid ratios are difficult. Standard and high powder–liquid-ratio materials have advantages such as ease of use, convenience, and homogeneous consistency.⁴

The use of different techniques in applying restorative materials has recently become more feasible. Initially, restorative materials are placed in cavities after pre-heating. Pre-heating the composite resins before the polymerization process has gained popularity among dentists as a way to improve the manipulation properties of the material during its insertion into the cavity.⁵ Pre-heating before photo-activation reduces the viscosity of composites, which has been shown to improve the marginal adaptation of the material and reduce microleakage due to increased adaptation to the cavity walls.⁶ In addition, increasing the polymerization temperature increases the

mobility of both radicals and monomers, resulting in a higher rate of polymerization. This approach can improve physical and mechanical properties such as higher surface hardness and increased diametral tensile strength and flexural strength of composite resins.⁷ However, it has been reported that heat application increases the microshear bond strength of composite resins to the dentin.⁸

The pre-heating applied to composite resins can also be applied to glass ionomer restorative materials. Heat curing is a relatively new technique that uses radiant heat to accelerate the curing reaction of traditional glass ionomer cements. This technique helps overcome the early moisture sensitivity problem of glass ionomer cements. Some studies have investigated the effects of thermo-setting on the mechanical properties of various glass ionomer cements and reported an increase in surface microhardness and flexural strength.⁹ Researchers have stated that heat treatment increases the mobility of both polymer segments and reactive free radicals formed during polymerization, which increases the degree of conversion of monomers to polymers and allows the cross-linking of polymers to increase.¹⁰ To date, limited studies have evaluated the bond strength of pre-heated glass ionomer cements.¹¹⁻¹⁴

Vital pulp treatments aim to preserve the vitality of the pulp by directly covering the pulp tissue exposed for various reasons or specifically by providing tertiary dentin formation with capping material applied on the exposed pulp tissue.¹⁵ Various calcium silicate-based cements can be used as pulp capping material. One of them is Biodentine, a pulp capping material containing bioactive calcium silicate. Biodentine has been developed as a new tricalcium silicate-based inorganic restorative cement.¹⁶ The most important advantages of Biodentine over mineral trioxide aggregate (MTA) are its clinical ease of use, high viscosity, less color change, short setting time (12 min), and better physical properties¹⁷ include having denser particles and less porous structures.¹⁸ Biodentine's microhardness, bending and compressive strength values are better than calcium silicate cements, so it is thought that biodentine can be used as an alternative to glass ionomer cements in restorative dentistry.¹⁹ Considering these advantages, the use of Biodentine in dental clinics tends to increase.

Sufficient bond strength of pulp capping agents and base materials to restorative materials is important for clinical success. The aim of this study was to evaluate the shear bond strength (SBS) of restorative materials applied to base materials and pulp capping agents using different techniques *in-vitro*.

The first null hypothesis of the study was that the placement technique would not affect the bond strength. The second null hypothesis was that the bond strength of pulp capping agents and base materials to restorative materials would not differ.

MATERIALS AND METHOD

The materials used in the study are shown in Table 1. Sample size calculations based on a 50% effect size, 80% power, and a 5% type 2 error level, suggested inclusion of at least 9 specimens in each group. Considering possible data losses, 10 specimens were planned for each group. G*Power (v. 3.1.9.6.; Franz Faul, Universitat Kiel, Germany) package program was used for specimen size calculations for all statistical analyses.

In this study, the SBS of restorative materials applied to base materials and pulp capping agents was evaluated. A chemically cured acrylic resin was mixed at

the rate recommended by the manufacturer and placed in a polyvinylchloride cylinder to form the molds in which the base material and pulp capping agent will be placed. The previously prepared silicone mold with a depth of 2 mm and a diameter of 4 mm was placed in the middle of the acrylic resin. After completion of the polymerization of the acrylic resin, the silicone mold was removed with a probe. In this way, acrylic blocks containing a total of 80 cylindrical cavities were obtained. A transparent plastic tube with a diameter of 2 mm and a height of 4 mm was used to apply fiber-reinforced composite resin (EverX Posterior, GC, Tokyo, Japan) and high-viscosity glass ionomer cement (Fuji IX, GC, Tokyo, Japan) to either the base material (Fuji II LC, GC, Tokyo, Japan) or pulp capping agent (Biodentine, Septodont, St. Maur Des Fosses, Val-de-Marne, France) with universal bonding agent (G-Premio Bond, GC, Tokyo, Japan) used in self-etch mode.

The acrylic blocks were divided into two groups for base material and pulp capping agent placement. Thereafter, the blocks were divided into four subgroups according to the restorative materials to be placed on these materials using different techniques (n=10).

Table 1. Materials used in the study

Material Name	Manufacturer	Content
EverX Posterior (EXP)	GC, Tokyo, Japan	Bis-GMA, PMMA, TEGDMA, short e-glass fiber filler, barium glass (74.2% by weight, 53.6% by volume)
Fuji IX (FIX)	GC, Tokyo, Japan	Powder: Aluminosilicate glass, polyacrylic acid Liquid: Polyacrylic acid, water
G-Premio Bond	GC, Tokyo, Japan	Acetone (25-50%), 2-hydroxy-1,3 dimethacryloxypropane (10-20%), methacryloyloxydecyl dihydrogen phosphate (5-10%), 2,2-ethylenedioxydiethyl dimethacrylate (1 5%), diphenyl(2,4) ,6-trimethylbenzoyl)-phosphine oxide (1-5%), 2,6-di-tert-butyl-p-cresol (<0.5%).
Biodentine (BD)	Septodont, Saint-Maur-des-fossés, Val-de-Marne, France	Powder: Ca ₃ SiO ₅ (> 80%), CaCO ₃ , ZrO ₂ Liquid: Water, CaCl ₂ , partially modified polycarboxylate.
Fuji II LC (FLC)	GC, Tokyo, Japan	Powder: Al ₂ O ₃ -SiO ₂ -CaF ₂ glass and HEMA urethane dimethacrylate. Liquid: Polyacrylic acid

*Abbreviations: Bis-GMA, bisphenol A glycidyl methacrylate; PMMA, polymethyl methacrylate; TEGDMA, triethylene glycol dimethacrylate; Ca₃SiO₅, tricalcium silicate; CaCO₃, calcium carbonate; ZrO₂, zirconium dioxide; CaCl₂, calcium chloride; Al₂O₃, aluminium oxide; SiO₂, silicon dioxide; CaF₂, calcium fluoride; HEMA, hydroxyethyl methacrylate.

-Pulp capping agent (pulp capping agent with bioactive calcium silicate: Biodentine) (n=40)

- Group 1a (n=10): Control fiber-reinforced composite resin (EverX Posterior) [BD - EXP]
- Group 1b (n=10): Heat-treated fiber-reinforced composite resin (EverX Posterior) [BD - EXP]
- Group 2a (n=10): Control high-viscosity glass ionomer cement (Fuji IX) [BD - FIX]
- Group 2b (n=10): Heat-treated high-viscosity glass ionomer cement (Fuji IX) [BD - FIX]

-Base material (resin-modified glass ionomer cement: Fuji II LC) (n=40)

- Group 3a (n=10): Control fiber-reinforced composite resin (EverX Posterior) [FLC - EXP]
- Group 3b (n=10): Heat-treated fiber-reinforced composite resin (EverX Posterior) [FLC - EXP]
- Group 4a (n=10): Control high-viscosity glass ionomer cement (Fuji IX) [FLC - FIX]
- Group 4b (n=10): Heat-treated high-viscosity glass ionomer cement (Fuji IX) [FLC - FIX] (Table 2).

Table 2. Groups included in the study

Base Material/Pulp Capping Material	Restorative Material	Control	Heat
BD	EXP	1a	1b
BD	FIX	2a	2b
FLC	EXP	3a	3b
FLC	FIX	4a	4b

The base material and pulp capping agent were placed in cavities with a depth of 2 mm and a diameter of 4 mm in accordance with the manufacturer's instructions. The resin-modified glass ionomer cement used as the base material was polymerized using an LED light device (D-Light Pro, GC Europe N.V., Leuven, Belgium) in accordance with the manufacturer's instructions.

After the preparation of the materials, the bonding procedure of the restorative materials was carried out after polymerizing the resin-modified glass ionomer cement with light, in accordance with the manufacturer's instructions and in accordance with clinical use. In the Biodentine groups, the bonding procedure of the restorative materials was conducted after waiting

12 minutes for the Biodentine to set, in accordance with the manufacturer's instructions and in accordance with clinical use. Thereafter, universal adhesive (G-Premio Bond, GC, Tokyo, Japan) was applied to the surface of the base material and pulp capping agent in groups 1a and 3a in accordance with the manufacturer's instructions. After 10 s, it was dried for 5 s and polymerized for 10 s using the LED light device. The fiber-reinforced composite resin was placed on the adhesive-applied specimen surfaces using a 2-mm-diameter and 2-mm-depth high transparent plastic tube in accordance with the manufacturer's instructions and polymerized using the LED light device. In groups 2a and 4a, a cavity surface conditioner (Cavity Conditioner, GC, Tokyo, Japan) was applied to the surface of the base material and pulp capping agent for 10 s in accordance with the manufacturer's instructions, rinsed with water, and dried gently with air pressure. High-viscosity glass ionomer cement (Fuji IX, GC, Tokyo, Japan) was mixed in the amalgamator (Linea Tac, Montegrosso, Italy) for 10 seconds in accordance with the manufacturer's instructions, and then bonding to the base material and pulp capping agent using a transparent plastic tube with a diameter of 2 mm and a height of 4 mm. In groups 1b, 2b, 3b, and 4b, the restorative materials were placed on the base material and pulp capping agent using a transparent plastic tube after being kept in water at 50°C (the temperature of the water was kept constant with the help of a thermocouple). The specimens in groups 1b and 3b were polymerized using the LED light device.

The prepared specimens were kept in the oven at 37°C for 24 h. The bond strength test was performed using a universal testing device (Schimadzu IG-IS, Kyoto, Japan) under 1 mm/min head speed until fracture occurred. The values obtained in Newton were divided by the bonding surface area of the materials and converted into megapascals. The fracture surface areas of the specimens were examined using a stereomicroscope (Olympus SZ-40, Tokyo, Japan) at 40× magnification. The fracture types were determined according to the following classification, and the data obtained were recorded.

- Adhesive Fracture: 75% or more of the fracture is between the base/pulp capping material and the restorative material.
- Cohesive Fracture from Base/Pulp Capping Ma-

terial: 75% and more of the breakage is in the base/pulp capping material itself.

- Cohesive Fracture from Restorative Material: 75% and more of the fracture is in the restorative material itself.
- Mix Fracture: Mixed failure is observed between the base/pulp capping material-adhesive-restorative material.

Statistical Analysis

IBM SPSS version 22 was used for statistical analysis. The conformity of data distribution to normal distribution was evaluated using the Shapiro-Wilk test. Three-way ANOVA was used to evaluate the effect of base material (FLC)/pulp capping agent (BD), restorative material (EXP-FIX) and application technique (control-heat) on bond strength. For application technique (control-heat), one-way ANOVA was used to compare individual parameters between groups and Grawes-Howell test was used to determine the groups of base material (FLC)/pulp capping agent (BD) or restorative material (EXP-FIX) that caused the difference. Chi-square test of independence was used to compare qualitative data. Significance was evaluated at $p < 0.05$.

RESULTS

The Shapiro-Wilk test revealed that the parameters had a normal distribution.

According to the three-way ANOVA results; There was a statistically significant difference in bond strengths between the base materials ($p < 0.001$; $p < 0.05$). There was a statistically significant difference in bond strengths between the restorative materials ($p < 0.001$; $p < 0.05$). There is no statistically

significant difference in bond strengths between the application techniques ($p < 0.53$; $p > 0.05$). The joint effect of the base material and restorative material on bond strength was statistically significant ($p < 0.001$; $p < 0.05$). The joint effect of the base material and application technique on bond strength was not statistically significant ($p < 0.16$; $p > 0.05$). The joint effect of the restorative material and application technique on bond strength reached statistical significance ($p < 0.016$; $p < 0.05$). The joint effect of the base material, restorative material and application technique on bond strength was not statistically significant ($p < 0.13$; $p > 0.05$) (Table 3).

In control groups (Groups 1a, 2a, 3a, and 4a); A statistically significant difference was found between the groups in terms of bond strength ($p < 0.001$; $p < 0.05$). The post-hoc Grawes-Howell test conducted to determine which groups the significance originated from revealed that the bond strength of Group 3a was higher ($p < 0.05$) than Group 1a ($p = 0.002$), Group 2a ($p = 0.002$) and Group 4a ($p < 0.001$). The bond strength of Group 4a was significantly lower ($p < 0.05$) than Group 1a ($p < 0.001$), Group 2a ($p = 0.013$) and Group 3a ($p < 0.001$). There was no significant difference between Group 1a and Group 2a ($p > 0.05$) (Table 4, Figure 1).

In groups where heat was applied (Groups 1b, 2b, 3b, and 4b); A statistically significant difference was found between the groups in terms of bond strength ($p < 0.001$; $p < 0.05$). The post-hoc Grawes-Howell test conducted to determine which groups the significance originates from showed that the bond strength of Group 3b was higher ($p < 0.05$) than Group 1b ($p = 0.007$), Group 2b ($p < 0.001$) and Group

Table 3. Three-way ANOVA test evaluation results

Bond Strength	Type III Sum of Squares	df	Mean Square	F	p
Base material	93.49	1	93.49	12.93	0.001*
Restorative material	1064.34	1	1064.34	147.27	0.001*
Application technique	2.82	1	2.82	0.39	0.53
Base material * Restorative material	397.21	1	397.21	54.96	0.001*
Base material * Application technique	14.45	1	14.45	2.00	0.16
Restorative material * Application technique	43.99	1	43.99	6.09	0.016*
Base material * Restorative material * Application technique	16.76	1	16.76	2.32	0.13

Three-Way ANOVA Test

* $p < 0.05$

Table 4. Evaluation of bond strength according to base material and restorative material separately in application techniques

	Bond Strength	
	Control (a)	Heat (b)
	MPa (Mean±SD)	MPa (Mean±SD)
Bondentine-EverX Posterior (Group 1)	5.27±1.27 ^A	6.44±2.96 ^A
Bondentine- Fuji IX (Group 2)	4.83±3.18 ^A	1.21±0.42 ^B
Fuji II LC -EverX Posterior (Group 3)	11.95±4.05 ^B	13.0±4.50 ^C
Fuji II LC-Fuji IX (Group 4)	0.77±0.58 ^C	0.68±0.35 ^D
F:	30.15	44.8
df	3	3
p	<0.001*	<0.001*

One way ANOVA Test

*p<0.05

Different capital letters in the columns indicate differences between groups.

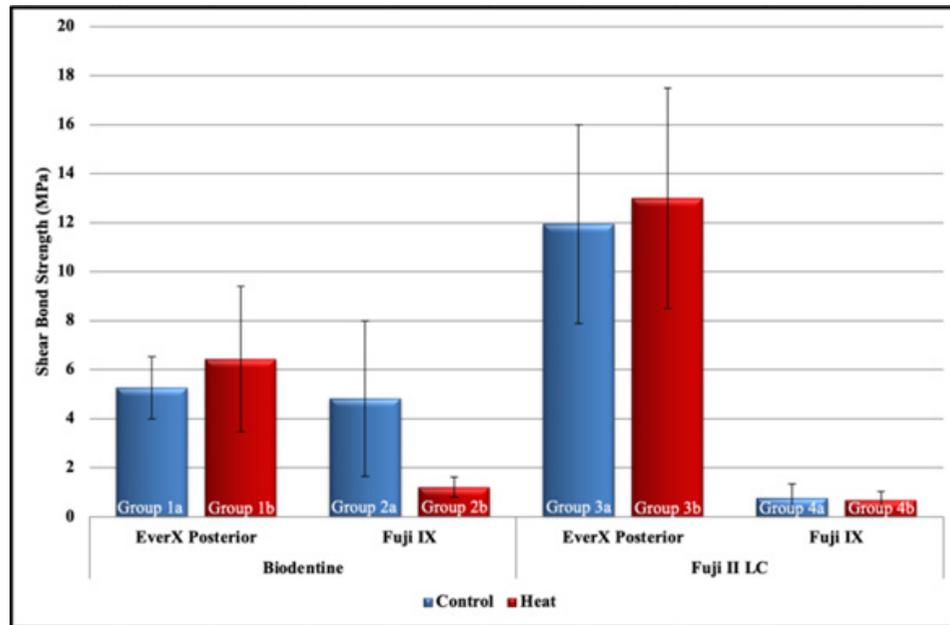


Figure 1. Shear bond strength values by groups

4b (p<0.001). The bond strength of Group 4b was found to be significantly lower (p<0.05) than Group 1b (p=0.001), Group 2b (p=0.033) and Group 3b (p<0.001). The bond strength of Group 1b was significantly higher than Group 2b (p=0.001; p<0.05) (Table 4, Figure 1).

To summarize briefly:

After pre-heating, the bond strength of EXP to BD (6.5±3.0 MPa) was significantly greater than that of FIX (1.2±0.4 MPa) (p<0.05). When BD and FIX were used, the bond strength without pre-heating (4.8±3.2

MPa) was statistically significantly higher than when pre-heating was performed (1.2±0.4 MPa) (p<0.05). When FLC material was used and no pre-heating was applied; the bond strength of EXP (12.0±4.1 MPa) was statistically significantly higher than that of the FIX (0.8±0.6 MPa) (p<0.05). When FLC and FIX are used; there was no statistically significant difference in terms of bond strength between the application techniques (p>0.05). When FLC material was used, the bond strength values of EXP material were found to be higher than FIX material, regardless of the application technique.

Table 5. Separate evaluation of fracture types according to base material and restoration material in application techniques

Fracture Type		Biodentine- EverX Posterior (Group 1)	Biodentine- Fuji IX (Group 2)	Fuji II LC -EverX Posterior (Group 3)	Fuji II LC- Fuji IX (Group 4)	
		n (%)	n (%)	n (%)	n (%)	p
Control (a)	Cohesive Fracture from Base	0 (0)	2 (20)	0 (0)	0 (0)	χ^2 :24.245 df:6 p<0.001
	Cohesive Fracture from Restoration	2 (20)	0 (0)	7 (70)	0 (0)	
	Adhesive Fracture	8 (80)	8 (80)	3 (30)	10 (100)	
Heat (b)	Cohesive Fracture from Base	1 (10)	1 (10)	0 (0)	0 (0)	χ^2 :11.54 df:6 p:0.073
	Cohesive Fracture from Restoration	0 (0)	0 (0)	3 (30)	0 (0)	
	Adhesive Fracture	9 (90)	9 (90)	7 (70)	10 (100)	

Pearson Chi-Square Test

*p<0.05

Considering the fracture types, the group in which the cohesive fracture from the restoration was statistically significant was group 3a, wherein EverX Posterior was applied on Fuji II LC without heating ($p<0.05$) (Table 5).

DISCUSSION

This study demonstrated that heating affected the bond strength of the glass ionomer-based restorative material, so the first null hypothesis was rejected. Further, the bond strength of the fiber-reinforced composite resin was greater in all groups than that of the glass ionomer-based restorative material. Consequently, the second null hypothesis was also invalidated.

Sometimes, it is not easy for clinicians to predict the prognosis when the pulp becomes exposed in the tooth to be restored. Therefore, researchers are attempting to find ways to preserve the vitality of the pulp using biocompatible materials such as calcium silicate-based cement, which provides a strong barrier against microleakage. Biodentine is a new calcium silicate-based pulp capping agent that sets faster and has improved mechanical properties compared with MTA. After pulp capping, the treated tooth needs a suitable final restoration, for which glass

ionomer-based materials or composite resins are commonly used.²⁰ Therefore, in addition to the bioactivity, biocompatibility, and remineralization properties of pulp capping agents, their bond strength to restorative materials is also an important factor. Proper bonding of composite resins to pulp capping agents ensures that the stress that may affect the bonding interface is spread relatively evenly.²¹

Glass ionomer cements have been widely used as base materials under composite resins since the introduction of the sandwich technique by McLean *et al.*²² Recently, high-viscosity glass ionomer restorative materials have been developed to increase the wear resistance of conventional glass ionomer cements, strengthen their low mechanical properties, and increase their indications limited to class I and V restorations.⁴ Thus today, resin-containing materials have become more questionable due to the fact that current glass ionomer cements show physical and mechanical properties comparable to dental amalgam in posterior teeth and the increasing biocompatibility concerns in the dental community in general. For this reason, the popularity of glass ionomer cements is increasing.²³ In addition, the potential for fluoride release to dental tissues, along with biological and chemical compatibility, has made glass ionomer cements a special group of materials in terms of caries prevention.²⁴ Fuji IX, a high-visco-

sity glass ionomer restorative material that can be used as a permanent restorative material in children, especially owing to its fluoride release feature, and in restorative procedures applied in adults owing to its advanced physical and mechanical properties, was preferred in this study.

Composite resins are the most frequently preferred restorative materials by dentists. Researchers have developed fiber-reinforced composite resin materials to increase the retention time and clinical success of conventional particle-filled composite resins for large restorations in posterior regions.² Restorative materials can be applied to dental tissues using different techniques. One of these techniques is heating such materials.

Many studies have revealed that heating reduces the viscosity of composite resins, increases the microhardness and degree of monomer conversion, and improves marginal adaptation in direct and indirect restorations.²⁵ In this study, the aim was to evaluate the effect of heating on the bond strength of restorative materials to pulp capping agents and base materials. EverX Posterior showed better adhesion to Fuji II LC than to Biodentine in both the control and heated groups. The bond strength between Biodentine and RMGIC and composite resin depends on the physicochemical properties and the nature of the bond between these materials. In the *in-vitro* study by Deepa *et al.*²⁶, it was observed that the bond strength of RMGIC to composite resin was greater than that to Biodentine, consistent with our results. RMGIC is photo-activated and shows early cohesion resistance owing to this photo-activation. In addition, the reason why the bond strength of composite resin and RMGIC is greater may be that they have a similar resin chemistry that supports chemical bonding between them. Hydroxyethyl methacrylate (HEMA), included in the RMGIC structure, forms a chemical bond with composite resin. In addition, the resin-containing adhesive agent forms a strong bonding interface by chemically bonding to both composite resin and RMGIC.²⁶ In the meta-analysis of Manoj *et al.*²⁷, it was reported that the bond strength of composite resin to RMGIC was higher than Biodentine, MTA and TheraCal LC. RMGIC has been reported to be chemically bonded to the resin composite by copolymerization of the unreacted monomer (HEMA) contained in the

oxygen inhibition layer formed on the outer surface of the cured RMGIC with adhesive systems or composite resins. One reason for the lower bond strength of Biodentine to composite resin may be the low bond strength of immature Biodentine material in the early setting stage. A period of at least two weeks is needed for the crystalline structure of Biodentine to accurately form and reach sufficient strength to withstand polymerization stresses.¹⁸ However, the manufacturer states that the restorative material can be applied after the material has a setting time of 12 minutes. Therefore, this study was designed according to the procedure routinely applied in the clinic.

Unlike resin-containing materials, heated glass ionomer cements show increased viscosity. Heating may increase the rate of ion diffusion, speed up the reaction, and reduce the working time and setting time. However, after the GIC is mixed, heat improves the physical and chemical properties of the material.²⁸ In the present study, the bond strength to Biodentine decreased when pre-heating was applied to the high-viscosity glass ionomer restorative material. Pre-heating of glass ionomer materials is known to reduce both the curing time and working time.²⁸ Based on our findings, it may be that the decrease in the bond strength of the high-viscosity glass ionomer restorative material to Biodentine after pre-heating is caused by the insufficient bonding due to the earlier completion of the curing reaction.

In our study, low bond strength values were observed between the RMGIC and the high-viscosity glass ionomer restorative material regardless of the application technique. To our knowledge, no study has yet evaluated the bonding of two different glass ionomers. Conventional glass ionomer cement consists of powder and liquid. Aluminum, silicon, and calcium are the three primary constituents of the glass particle. Aluminum oxide and silicon dioxide form the skeleton of the glass. This material has a tetrahedral structure with a three-dimensional silicate structure. In general, zinc oxide and strontium oxide replace calcium oxide.⁴ Hydrophilic monomers and polymers such as HEMA have been added to the chemical structure of resin-modified glass ionomer cements to strengthen the mechanical properties of the material.²⁹ This difference in chemical structure may prevent adhesion between the two materials.

Heating of resin-containing materials increases the conversion rate of monomers to polymers and the surface microhardness value without accelerating the time at which maximum polymerization is achieved. This improvement is probably attributed to the increased molecular mobility and collision frequency of reactive molecules. In the study by Covey *et al.*¹⁰, the effect of heat application on the diametral tensile strength of composite resins was evaluated, and it was noted that heating had a positive effect on the diametral tensile strength. The researchers stated that heating composite resins minimized tooth-restoration interface stresses and marginal cavity formation caused by polymerization shrinkage. In this study, it was observed that heating EverX Posterior did not cause a significant change in the bond strength when the same base material or pulp capping agent was used. After the composite resin specimens were prepared, they were kept in the oven at 120°C for 7 min. The difference in the results of the study may be attributed to the difference in the amount of heat applied and the time and procedure of heating after the material polymerized. In addition, a fiber-containing composite resin was used in our study. The addition of fiber to the composite resin structure can also affect the bond strength of the material, as it can change the viscosity. Therefore, the difference in the results from the related study may be attributed to the differences in the structure of the restorative materials and adhesives used.

This study has some limitations due to the nature of *in-vitro* research. The limitation of this study is that no aging procedure was applied, which may affect the long-term bonding success of restorative materials after clinical application. Although this study does not include this procedure, it is among the limited number of studies evaluating the bond strength of restorative materials applied with different techniques to the base material and pulp capping agents.

CONCLUSIONS

Within the limitations of the current study, it was concluded that: Heating affects the bond strength of fiber-reinforced composite resins.

Heating fiber-reinforced composite resins can positively affect the bond strength to bioactive calcium silicate pulp capping agent.

Light-cured base materials can be used owing to their greater bond strength to fiber-reinforced composite resins.

Heating of glass ionomer-based restorative materials may reduce their bond strength.

The use of light-cured glass ionomer base materials under glass ionomer-based restorative materials may not be appropriate owing to their low bond strength values.

Considering the results obtained from this study; heating of fiber-reinforced composite resins before the restorative procedure can be recommended because it can positively affect the bond strength of the material to the underlying bioactive calcium silicate pulp-capping agent. In addition, if a restoration with a fiber-reinforced composite resin is planned, it is recommended that the base material be a light-cured based materials in order to obtain better bond strength. However, if a restoration is planned with a glass ionomer-based material, we do not recommend pre-heating as it negatively affects the bond strength of the material.

CONFLICTS OF INTEREST STATEMENT

The authors report no conflicts of interest to declare.

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Case Report

Can MTA Resolution Affect the Prognosis of Regenerative Endodontic Procedures in Long Term: Case Report

MTA Çözünürlüğü Rejeneratif Endodontik İşlemlerin Uzun Vadede Prognozunu Etkileyebilir mi?: Vaka Raporu

Alev Alaçam¹ , Şeyma Yıldırım İşen² 

ABSTRACT

Introduction: This report aims to evaluate the clinical and radiological results of cases in which Mineral Trioxide Aggregate (MTA) was found to dissolve in the root canals in the long term after Regenerative Endodontic Procedures (REP).

Case Report: The first case is an 8-year-old boy who applied to our clinic with the diagnosis of symptomatic pulpitis in the lower left first molar. The second case was an 11-year-old girl with asymptomatic necrosis in her left lower jaw second molar. The prescribed method of treatment was blood clot revascularization. In both cases, triple antibiotic paste, and MTA were used for REP. After four to six years of follow-up, the teeth were clinically asymptomatic, but radiographic evaluation showed resolution of the MTA in both cases. While root development was considered complete in the first case, root dilaceration was observed in the second case.

Conclusion: The evaluation of these cases suggested that, despite long-term clinical adverse effects, MTA dissolution did not affect the clinical and radiographic success of REP treatments.

Keywords: MTA; Porosity; Regenerative endodontic procedure; Resolution; Solubility

ÖZET

Giriş: Bu rapor, rejeneratif endodontik prosedürler (REP) sonrası uzun vadede Mineral Trioksit Agregat'ın (MTA) kök kanallarında çözüldüğü saptanan olguların klinik ve radyolojik sonuçlarını değerlendirmeyi amaçlamaktadır.

Vaka Raporu: İlk olgu, sol mandibular birinci büyük azı dışında semptomatik pulpitis tanısı ile kliniğimize başvuran 8 yaşında erkek çocuğu, ikinci olgu ise sol mandibular ikinci büyük azı dışında asemptomatik nekroz olan 11 yaşında bir kız çocuğuydu. Tedavi için öngörülen yöntem kan pıhtısı revaskülarizasyonuydu. Her iki olguda da REP için üçlü antibiyotikli pat ve MTA kullanıldı. Dört ila altı yıllık takip süresinin ardından dişler klinik olarak asemptomatikti, ancak radyografik değerlendirme her iki olguda da MTA'nın çözüldüğünü gösterdi. İlk olguda kök gelişimi tamamlanmış kabul edilirken, ikinci olguda kök dilesasyonu gözlemlendi.

Sonuç: Bu olguların değerlendirilme sonuçları, uzun vadede klinik olumsuzluklara rağmen MTA çözünmesinin REP tedavilerinde klinik ve radyografik başarıyı etkilemediğini göstermiştir.

Anahtar Kelimeler: Çözünme; Çözünürlük; MTA; Porözite; Rejeneratif endodontik uygulama

Makale gönderiliş tarihi: 18.02.2025; Yayına kabul tarihi: 18.04.2025

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INTRODUCTION

Regenerative endodontic procedure (REP) is a valuable alternative for endodontic treatment of teeth with open apices. Also, it is a good alternative to apexification, increasing root thickness and length. This procedure includes the debridement of tissues from the root canal, disinfection, and instrumentation of the periapical tissues through the open root apex to cause bleeding into the canal and revascularization. Blood clot induction, also known as revascularization, is a commonly used technique in REPs. It introduces a scaffold or biological procedure recruiting stem cells around the root to proliferate, differentiate, and promote the formation of vital tissue. This tissue will continue the deposition of minerals needed for thick dentin walls and root growth. One of the crucial steps for success in the clinical protocol of REPs is to close the tooth canal tightly. Mineral trioxide aggregate (MTA) is the most popular sealing material in REP with an excellent overall survival rate.¹ It is the gold standard with good properties, but its solubility is debated among investigators.^{2,3} On the other hand, few studies deal with void structures of sealing materials used in REPs.^{4,5} However, the clinical effects of structural loss in bioceramic materials after clinical applications should be considered as an area that needs further exploration.

In this report, the causes and consequences of MTA filler resolution and the progression of root development are evaluated in a long-term follow up after REP.

CASE REPORT

This case report has been written according to the preferred Reporting Items for Case Reports in Endodontics (PRICE) 2020 guidelines⁶. This study conducted on an overview of the regenerative therapies in Gazi University Dentistry Faculty Pediatric

Dentistry Clinics with ethical approval between 2017 and 2023. The clinical and radiographical data were extracted from the PACS system of the Faculty of Dentistry and the clinical forms specific to REPs. Patient approval and parent consent for the treatment were obtained before the regenerative endodontics routine.

Steps were standardized according to the AAE Clinical Considerations for a Regenerative Procedure guideline⁷ to accomplish regenerative endodontics. The case selection of REP was done using a standard protocol for teeth with necrotic pulp and irreversible pulpitis. Blood clot revascularization was the proposed method for revascularization.

Triple antibiotic paste 1:1:1 ciprofloxacin: metronidazole: clindamycin to a final concentration of 0.1-1.0 mg/ml. was used as root canal disinfectant. Finally, the root canal orifice was filled with a 2 mm thick layer of MTA (BİOMTA, Cerkamed, Poland) in contact with the scaffolds. MTA was mixed with its solvent according to the manufacturer's instructions, incrementally placed into the canal orifices, and compacted using endodontic pluggers (Dentsply Caulk, Milford, DE). The pulp chamber was filled with glass ionomer cement (Nova Glass-F, IMICRYL, LLC, USA). According to the indication, the teeth were restored with amalgam, composite, or stainless-steel crown. The flow chart for reporting these case reports is given in Figure 1. Healing of the cases, according to Chen *et al.*⁸ was given in Table 1.

The first case was an 8-year-old boy who was referred to our clinic, suffering from major coronal destruction and spontaneous night pain in his left mandibular first molar teeth (12.06.2017). His medical history was unremarkable. Intraoral examination records showed deep dentin caries with wide coronal destruction. Incomplete root maturation, besides deep caries, was seen in the radiographic

Table 1. Responses of immature permanent teeth with infected necrotic pulp tissue and either apical periodontitis or abscess to revascularization procedures according to Chen *et al.*⁸

Type 1	There was increased thickening of the canal walls and continued root maturation
Type 2	There was no significant continuation of root development, and the root apex became blunt and closed
Type 3	There was continued root development, and the apical foramen remained open
Type 4	There was severe calcification (obliteration) of the canal space
Type 5	There was a hard tissue barrier formed in the canal space between the coronal MTA plugs and the root apex

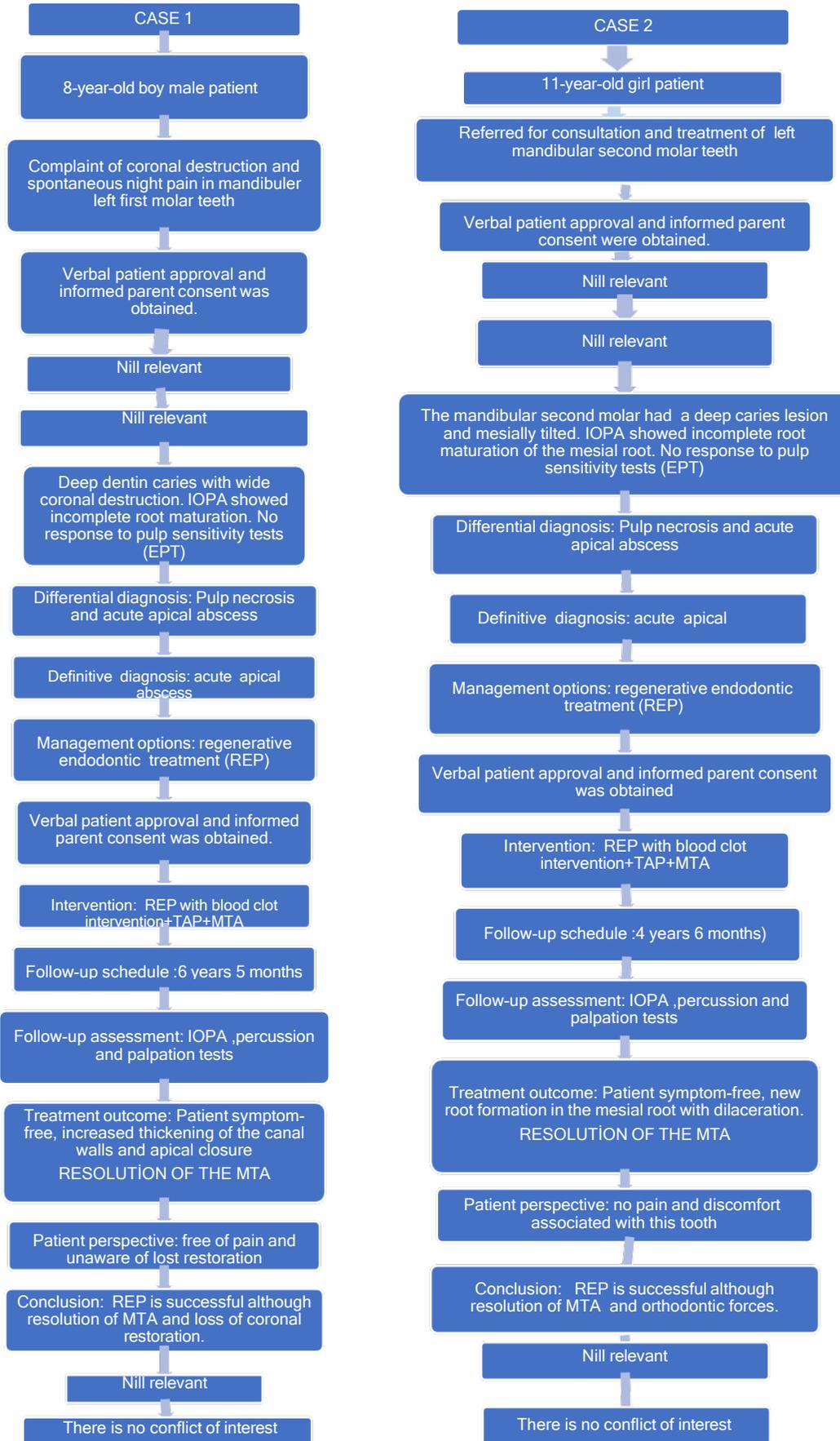


Figure 1. This flow chart from PRICE 2020 guidelines for reporting case reports in endodontics.



Figure 2 (a). Case 1, July 2017. (b). Case 1, December 2023

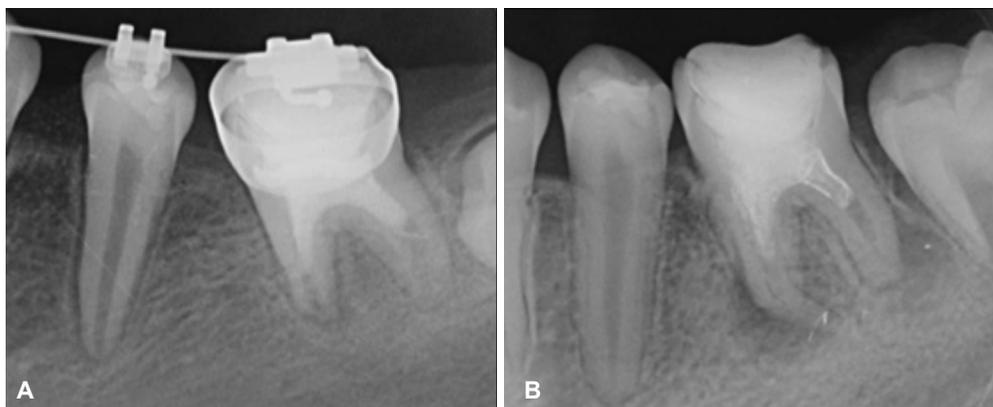


Figure 3 (a). Case 2, July 2019. (b). Case 2, February 2024

examination. There was no vitality response to the electrical pulp test. A pulpal diagnosis of necrotic pulp and periapical diagnosis of acute apical abscess was made for tooth 36. Based on clinical and radiographic findings, the tooth was suitable for regenerative endodontics. His regenerative treatment procedure was completed on 04.07.2017. The tooth was restored with amalgam (Figure 2 a). The patient did not return for a follow-up for six years and five months. When he came back on our recall (11.12.2023), the clinical examination showed a lost restoration of tooth 36 with an asymptomatic tooth. In the radiographic examination, a resolution of MTA, besides type 1 healing according to Chen *et al*⁸, was detected. (Figure 2 b). The patient stated he was unaware of lost restoration as he had no problem with the tooth.

The second case was an 11-year-old girl who was referred for consultation and treatment of the left mandibular second molar teeth. (02.07.2019) She had no general health problems according to med-

ical records. The patient had started an orthodontic treatment in a private clinic. Intraoral examination records showed multiple restorations and missing tooth 36. The left mandibular second molar had a deep caries lesion and was mesially tilted. The patient had no clinical complaints. Radiographically, tooth 37 had an immature mesial root. There was no vitality response in the electrical pulp test. A necrotic pulp and acute apical abscess were determined tooth 37. The tooth was important for orthodontic treatment planning and considered suitable for regenerative endodontics. The regenerative treatment procedure was completed on 23.07.2019 (Figure 3 a). The tooth was restored with a stainless-steel crown. The patient did not return for a follow-up until February 2024. After nearly four years and six months, the tooth was clinically asymptomatic, and orthodontic therapy was completed. The restoration was changed to an amalgam. The radiographic examination showed a new root formation in the mesial root with dilaceration (Figure 3 b). The patient did

not have any pain or discomfort associated with this tooth. Although there was a resolution in the MTA, clinical and radiographical results showed the success of REP despite orthodontic forces in the long term.

DISCUSSION

Regenerative endodontic therapy is the future of the endodontic treatment of immature permanent teeth. However, meta-analysis and systematic reviews indicate the need for a comparative analysis of the long-term effectiveness of REP and apexification.^{9,10} The importance of periodic appointments was underlined by most clinicians, pointing to a follow-up every three months during the first year, every six months for two years, and every 12 months for five years to evaluate the survival rate of the therapies.^{11,12} This case report had an unintentional follow-up 4 to 6-year period because the patients did not return until then.

In the first case, closure of the apical opening and root wall growth was observed after six years and six months conforming to type 1 healing of Chen *et al.*⁸ with increased thickening of the canal walls, and root maturation. In the second case, the mesialization forces affect the mesial root development of tooth 37 with a dilaceration, but root development continued with apical closure. Distal roots showed type 2 healing radiographically.

However, there was visible disintegration in the MTA radiographically in both cases, and this resolution of MTA in canal orifices in time was important due to the risk of microleakage. It is known that voids established inside the bioceramic materials serve as hubs for microorganisms, leading to microleakage and creating a potential cause of treatment failure after endodontic treatment. Thus, when investigating the reason, the literature pointed out a relationship between time and calcium ion release from MTA, which may affect the degree of solubility.^{13,14}

On the other hand, if a high water–powder ratio is used during mixing, excess water dries off and leaves voids not filled by hydration products. Fridland and Rosado^{15,16} stated that a higher water-to-powder ratio of the paste would increase calcium release from MTA, causing porosity and solubility. Cavenego *et al.*¹⁷ stated that more water (2: 1) had significantly

resulted in more material volume loss in their in vitro study. The BIO MTA used in these case reports had a solvent of purified water and calcium catalyst. The manufacturer proposes to mix BIO MTA powder with 1-2 drops of solvent for 30 seconds until the compound reaches a consistency of soft plasticine. The preparation of the paste might be affected by iatrogenic factors, resulting in voids following the hardening of the paste.

Moreover, MTA may be inadvertently mixed with blood during placement or encounter with blood during the setting. Milani *et al.*⁵ showed that exposure to blood negatively affects the marginal adaptation of MTA to dentin. Chung *et al.*¹⁸ stated that voids with a radius larger than 50 µm were clustered mainly in the upper part of the specimen, which was attributed to the bleeding phenomenon during the setting process. The treatment type may affect MTA disintegration because of blood contamination in the canal orifications, causing voids in the reported cases.

CONCLUSION

This case report presented a long-term follow-up of regenerative endodontic procedure of two molar teeth conducted with blood clot induction and MTA plug, healed with apical closure and root development even with some clinical challenges such as restoration loss and orthodontic forces. The success of the MTA plug, even with a resolution in time, was discussed.

ACKNOWLEDGEMENT

The authors would like to thank Gazi University Academic Writing Application and Research Center for proofreading the article.

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Case Report

A Case of Ludwig's Angina: A Rare and Potentially Lethal Neck Infection

Ludwig Anjina Vakası: Nadir Görülen ve Hayati Risk Oluşturan Boyun Enfeksiyonu

Recep Ünal¹ , Nur Mollaoğlu² 

ABSTRACT

Introduction: Ludwig's Angina (LA) is a rare, life-threatening infection of the mouth and submandibular spaces, mainly caused by odontogenic infections, particularly periapical abscesses in mandibular molars. The infection spreads through the submandibular and sublingual spaces, causing severe neck swelling, trismus, and difficulty swallowing. The pathogens involved are a mix of aerobic and anaerobic bacteria, including *Streptococcus viridans* and *Staphylococcus aureus*. Treatment focuses on securing the airway, followed by antibiotics and surgical drainage, with an emphasis on early intervention.

Case Report: A 25-year-old woman presented to our clinic with swelling, redness, and pain in the right and anterior regions of the jaw and both sides of the neck. On examination, a painful, firm swelling with redness, especially in the right submandibular and sublingual regions, limited neck mobility and trismus were observed. The patient was initially referred to the otorhinolaryngology department following a preliminary diagnosis of Ludwig's Angina, and the patient's lower impacted wisdom teeth were extracted following drainage of neck abscess.

Conclusion: Ludwig's Angina is a rapidly progressing, life-threatening infection of the submandibular and sublingual regions. Early diagnosis and intervention, including securing the airway, administering broad-spectrum antibiotics, and performing surgical drainage are crucial for successful outcomes and reducing mortality.

Keywords: Ludwig's Angina; Odontogenic infection; Surgical drainage

ÖZET

Giriş: Ludwig anjina (LA), submandibular, sublingual ve submental lojların nadir görülen, yaşamı tehdit eden bir enfeksiyonudur. Enfeksiyona esas olarak odontojenik enfeksiyonlar; özellikle mandibular molar dişlerin periapikal apseleri neden olur. İlgili lojlara yayılım nedeniyle boyunda ciddi şişlik, trismus ve yutma güçlüğü gözlenir. Patojenler *Streptococcus viridans* ve *Staphylococcus aureus* dahil olmak üzere aerobik ve anaerobik bakterilerdir. Tedavisi, erken müdahalenin önemi vurgulanarak hava yolunun güvence altına alınmasını takiben, antibiyotik profilaksisi altında cerrahi drenaj yapılmasıdır.

Vaka Raporu: 25 yaşında kadın hasta çenesinin sağ ve ön bölgesinde şişlik, kızarıklık ve ağrı ile kliniğimize başvurdu. Yapılan intraoral muayenede özellikle sağ submandibular ve sublingual bölgede boyunda ağrılı, kızarık, sert bir şişlik ile beraber boyun hareketlerinde kısıtlılık ve trismus saptandı. Hasta ilk olarak Ludwig anjina ön tanısıyla kulak burun boğaz bölümüne konsültasyon amaçlı sevk edildi ve boyun apsесinin drenajını takiben hastanın alt gömülü yirmi yaş dişleri çekildi.

Sonuç: Ludwig anjina hızlı ilerleyen, hayati tehlike oluşturan derin bir boyun enfeksiyonudur. Erken tanı ve hastanın zamanında hospitalize edilmesi mortaliteyi azaltmada önemli bir rol oynar.

Anahtar Kelimeler: Cerrahi drenaj; Ludwig anjina; Odontojenik enfeksiyon

Makale gönderiliş tarihi: 14.01.2025; Yayına kabul tarihi: 24.01.2025

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INTRODUCTION

Ludwig's Angina (LA) is a rapidly progressing, life-threatening infection of the floor of the mouth and submandibular spaces, first identified by German surgeon Karl Friedrich Wilhelm von Ludwig in 1836.¹ Odontogenic infections cause this severe cellulitis in 70% of the cases and typically affects adults with periapical abscesses originating from mandibular molars, although other risk factors include poor dental hygiene, trauma, immunosuppression, and systemic illnesses like diabetes and HIV.²

The infection commonly spreads through submental, sublingual, and submandibular spaces, causing severe neck swelling, trismus, and difficulty in swallowing. The cause of Ludwig's Angina is a mixture of aerobic and anaerobic bacteria normally present in the oral flora. These are mainly *Streptococcus viridans*, *Staphylococcus aureus*, β -hemolytic *Streptococcus* species and *Staphylococcus epidermidis*.^{3,4} Ludwig's Angina has the potential to cause airway obstruction. Treatment plan should prioritize ensuring and maintaining airway patency. Prophylactic antibiotic use and surgical drainage are the next steps in treatment.⁵



Figure 1. Facial swelling in a 25-year-old patient with Ludwig's Angina.

This article presents a rare case of Ludwig's Angina and the importance of immediate airway management and treatment modality based on the current literature.

CASE REPORT

A 25-year-old female patient presented to the Department of Oral and Maxillofacial Surgery with complaints of severe submandibular pain, difficulty in breathing, and a firm swelling primarily in the right side and middle of the jaw (Figures 1-2). Her medical history included visit to the clinic with bilateral pain and swelling in the jaw and prescription of clindamycin tablets six days ago. Physical examination revealed painful, firm swelling in the right submandibular and sublingual regions, trismus, dysphagia, and mild stridor. The patient exhibited a fever of 39.5°C and lymphadenopathy. Redness and pain were observed in the mucosa surrounding the lower wisdom teeth.

The patient was first referred to the Department of Otolaryngology for consultation with a preliminary diagnosis of Ludwig's Angina based on intra-extra oral clinical examination findings.

Computed tomography revealed a periapical abscess measuring 64×80 mm, located medially adjacent to the right mandibular corpus (Figure 3). The abscess extended into the parapharyngeal space and posteriorly to the anterior aspect of the right

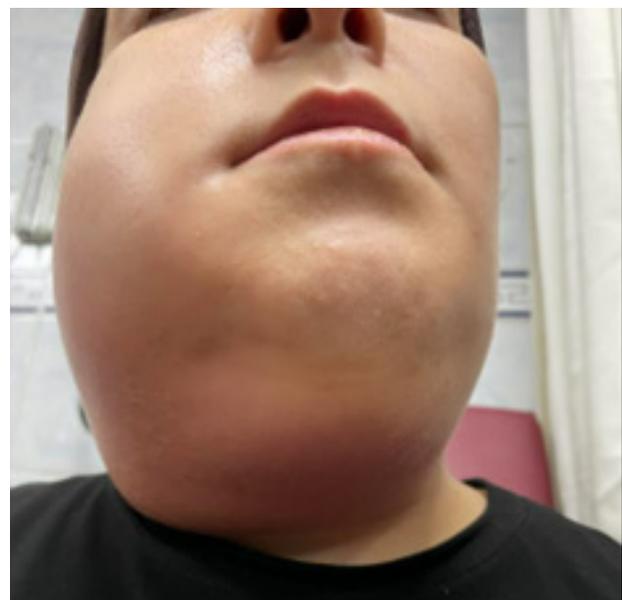


Figure 2. Swelling and redness in submandibular and submental triangles.

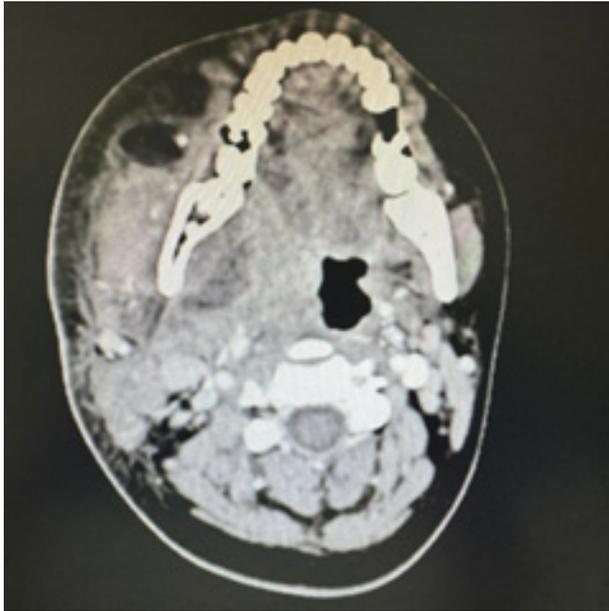


Figure 3. Extensive submandibular inflammation and edema on the right side of the neck.

parotid gland, with internal dense fluid densities. In the Department Otolaryngology, the patient was approached through a deep incision in the submandibular triangle followed by surgical drainage through the mylohyoid muscle and from the sublingual region. After the surgical drainage, the patient was administered ceftriaxone and metronidazole for seven days. Following neck drainage, the patient's infected right and left third molar teeth were extracted in two weeks later by obtaining the consent form.

DISCUSSION

Ludwig's Angina is a rapidly progressing, potentially life-threatening cellulitis that typically begins in the submandibular space and spreads along fascial planes to the sublingual, submylohyoid, and submental regions. It is most commonly caused by untreated dental infections, particularly those associated with poor oral hygiene, such as dental caries and abscesses in the first molar. Other potential sources of infection include sialadenitis, mandibular fractures, and tongue piercings. Predisposing factors include diabetes, malnutrition, obesity, alcohol use, and immunocompromised states.^{6,7}

The infection is polymicrobial, with oral cavity flora being the primary contributors. Viridans group Streptococci, *Staphylococcus aureus*, and *Staphylococcus epidermidis* are commonly involved.⁸ Symptoms often include dysphagia, dysarthria, neck

pain and difficulty swallowing, and can progress to severely compromised airway.^{9,10}

Early diagnosis is critical, as Ludwig's Angina can lead to fatal complications such as airway obstruction, sepsis, or mediastinitis. The mortality rate, once as high as 54-60%, has decreased to under 2% with early and aggressive intervention.^{10,11} Treatment typically involves airway management, broad-spectrum antibiotics, and surgical debridement. Airway protection is crucial, and elective awake tracheostomy may be considered a safer alternative to intubation in some cases. Adequate hydration, nutrition, and upright positioning are important, particularly in patients with oropharyngeal edema.^{9,12}

Imaging techniques such as ultrasonography, computed tomography (CT), and magnetic resonance imaging (MRI) are essential for early detection and to evaluate potential complications like abscesses or airway edema.⁷ While intravenous antibiotics alone may be effective in some early-stage cases, surgical debridement combined with antibiotics tends to result in better outcomes, especially in preventing airway compromise.

Prompt multidisciplinary management is essential to reduce the risk of severe complications and ensure favorable outcomes.

CONCLUSION

Ludwig's Angina is a rare but potentially lethal condition characterized by rapidly spreading cellulitis of the submandibular, sublingual, and submental spaces. Early diagnosis and prompt multidisciplinary management, including airway stabilization, aggressive antibiotic therapy, and surgical intervention when necessary, are critical to reducing morbidity and mortality. This case demonstrates that successful outcomes can be achieved with early diagnosis and treatment. Securing the airway, administering broad-spectrum antibiotics, and performing surgical drainage are essential components in managing Ludwig's Angina. As highlighted in the literature, prompt recognition and timely intervention are key to reducing the high mortality associated with this infection. An immediate hospitalization is warranted in most cases.

ACKNOWLEDGEMENTS

The authors would like to thank Gazi University Academic Writing Application and Research Center for proofreading the article.

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Case Report

Diagnosis and Dental Treatment Management in a Case of Late Latent Syphilis: A Case Report

Geç Latent Sifilis Olgusunda Teşhis ve Dental Tedavi Yönetimi: Bir Olgu Sunumu

Ecem Elif Çege¹, Mehmet Bani²

ABSTRACT

Introduction: Syphilis is a systemic disease, typically transmitted sexually and diagnosed via serological tests. Clinical findings within dental health include notched incisors, often referred to as Hutchinson incisors, and what are described as mulberry-shaped molars or Mulberry molars. Syphilis progresses through four phases: primary, secondary, latent, and tertiary, and it can be treated.

Case Report: An 11-year-old male patient presented to the clinic with a toothache. Clinical and radiographic examinations revealed incompletely erupted permanent molars, notched appearance incisors, and canines lacking a normal tubercle structure and enamel tissue. Serological testing led to the diagnosis of late latent syphilis in the patient and his family. Consequently, treatment with benzathine penicillin G commenced. Dental treatment encompassed oral hygiene training, extraction of molars with severe material loss, and restoration with anterior strip crowns. This case report outlines the process of diagnosing late latent syphilis and the dental treatment of a boy whose oral findings suggested a pre-diagnosis of syphilis.

Conclusion: Dentists must accurately diagnose the oral manifestations of systemic diseases like syphilis. Early diagnosis and treatment can halt the disease's progression and prevent its spread.

Keywords: Hutchinson incisor; Mulberry molar; Syphilis

ÖZET

Giriş: Sifilis genellikle cinsel yolla bulaş gösteren sistemik bir hastalıktır. Teşhis, genellikle serolojik testlerle yapılır. Konjenital sifilisin ağız içi klinik bulgularından birisi çentikli görünüme sahip kesici dişler (Hutchinson keser) iken bir diğeri dut şeklinde azı dişleridir (Mulberry molar). Sifilis; primer, sekonder, latent ve tersiyer sifilis olmak üzere başlıca dört döneme ayrılan ve tedavi edilebilir bir hastalıktır.

Vaka Raporu: On bir yaşında erkek hasta diş ağrısı şikayetiyle kliniğe başvurmuştur. Klinik ve radyografik muayenede, normal tüberkül yapısı ve mine dokusu olmayan, tam sürememiş daimi molar dişler ile çentikli kesici ve kanin dişler tespit edilmiştir. Yapılan serolojik testler sonucunda hastaya ve ailesine geç latent sifilis teşhisi konulmuş ve Benzathine Penisilin G tedavisi başlanmıştır. Dental tedaviler arasında ağız hijyeni eğitimi, aşırı madde kaybı olan molar dişlerin çekimi ve anterior strip kronlarla yapılan restorasyonlar yer almıştır. Bu olgu sunumunda, oral bulguları sifilis ön tanısını düşündüren erkek çocuğun geç latent sifilis teşhisi konulma süreci ve dental tedavileri anlatılmaktadır.

Sonuç: Diş hekimlerinin sifilis gibi sistemik hastalıkların ağız içi bulgularını teşhis edebilmesi son derece önemlidir. Bu sayede, erken tanı ve tedavi sonucunda hastalığın ilerlemesi ve yayılması önlenmiş olmaktadır.

Anahtar Kelimeler: Mulberry molar; Hutchinson keser; Sifilis

Makale gönderiliş tarihi: 05.08.2024; Yayına kabul tarihi: 03.03.2025

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INTRODUCTION

Syphilis is an infectious disease caused by the anaerobic, filamentous spirochete *Treponema pallidum*. If syphilis is not diagnosed early and treated appropriately, it progresses through various clinical stages.¹ The disease is divided into four main phases: primary, secondary, latent, and tertiary syphilis. Diagnosis of syphilis typically involves serological tests.²

Congenital syphilis is an infectious disease caused by *Treponema pallidum*, which is transmitted from an untreated infected mother to her baby during pregnancy. Most children who are not treated within the first 6 to 12 months of life progress to latent and tertiary syphilis. Symptoms of late-stage syphilis can cause damage to bones, teeth, eyes, ears, and the brain.³

Manifestations of congenital syphilis include the Hutchinson triad, which is characterized by interstitial keratitis, eighth nerve deafness, and Hutchinson teeth.⁴ One of the clinical findings in the teeth is the notched appearance of incisors, known as Hutchinson incisors, while another finding is referred to as mulberry molars. Numerous rounded enamel ridges on the molars characterize mulberry molars. Usually, no treatment is required, but topical fluoride application and routine monitoring are recommended. In severe cases, a crown or extraction may be necessary.⁵

Penicillin G is utilized in the treatment of syphilis. For early latent syphilis, Benzathine penicillin G (2.4 million units, administered intramuscularly as a single dose) is used. For late latent syphilis, it is recommended to use Benzathine penicillin G (2.4 million units per week, administered intramuscularly for 3 weeks).⁶

This case report describes the process of diagnosing late latent syphilis and the dental treatments for a boy whose oral findings suggest a preliminary diagnosis of syphilis.

CASE REPORT

An eleven-year-old male patient was referred to the Gazi University Faculty of Dentistry Department of Pediatric Dentistry due to pain in his upper molar tooth. No systemic diseases were reported. The

clinical extraoral examination showed no pathology. Clinical and radiographic examination revealed incompletely emerged permanent molars lacking a typical tubercle structure and enamel tissue. Moreover, the patient's lower permanent incisors and canines indicated a notched appearance. Unfitting composite restorations were observed in the upper front teeth, accompanied by poor oral hygiene (Figure 1a-2). These findings raised suspicions of an initial diagnosis of syphilis.

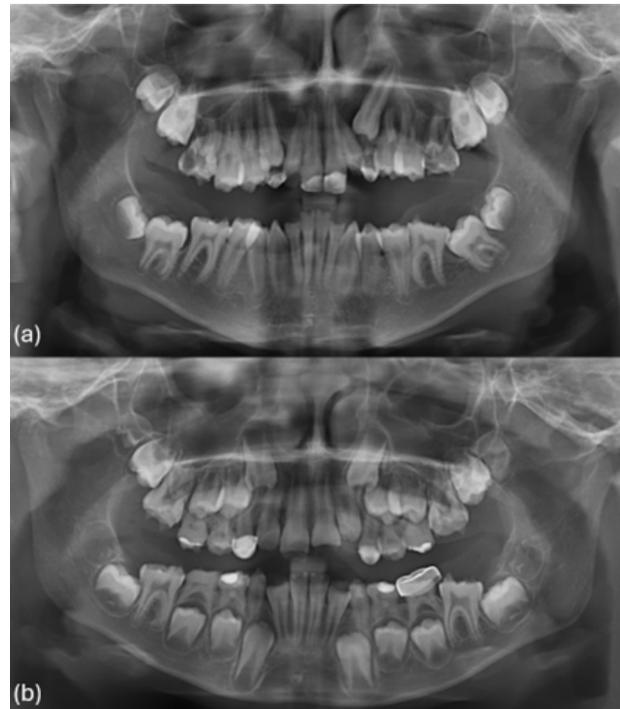


Figure 1. (a) Orthopantogram taken in 2022, (b) Orthopantogram taken in 2018.



Figure 2. Intraoral photographs.

Four years prior, panoramic radiographs revealed a notched appearance in the permanent incisors, known as Hutchinson incisors. In addition, both primary and permanent molar teeth were observed to lack enamel tissue and diverse cuspid structures, referred to as Mulberry molars (Figure 1b). The patient was subsequently referred to the Pediatric Infection Department at Gazi University's Faculty of Medicine with a preliminary diagnosis of syphilis. Both serological tests and bone examinations verified the diagnosis of Late Latent Syphilis. At roughly the same time, the patient's mother and sister also received diagnoses of syphilis.

The patient initiated treatment with Benzathine Penicillin G (2.4 million units/week, intramuscular) for 3 weeks, adhering to the late latent syphilis treatment protocol. This protocol was also administered to the patient's mother and sister, both diagnosed with syp-



Figure 3. Anterior teeth restored with anterior strip crowns.



Figure 4. Unsupported and sharp syphilitic teeth into a regular shape.

hilis. It was determined that the patient was not contagious, and dental treatments were started, utilizing standard infection control measures.

In the patient's dental treatment plan, training in oral hygiene was provided first, followed by the removal of dental plaque through scaling and polishing. Painful upper permanent first molars that had lost an excessive amount of material were extracted. Unsuitable anterior restorations were replaced. The Etch-Bleach-Seal technique was used on hypoplastic teeth, utilizing 37% phosphoric acid for 60 s, followed by 5% sodium hypochlorite, again for 60 s, and another 30-s application of 37% phosphoric acid. Anterior strip crowns were used to restore the anterior teeth (Figure 3).

The unsupported and sharply cusped syphilitic teeth were reshaped into a regular form, followed by fluoride application post-abrasion (Figure 4). Other carious teeth were restored using composite resin (Charisma Smart, Heraeus Kulzer, Germany).

It was noted that the patient had no complaints at the second year follow-up (Figure 5a-b). The patient received oral hygiene recommendations and was referred to the Gazi University Faculty of Dentistry's Department of Orthodontics for orthodontic treatment.

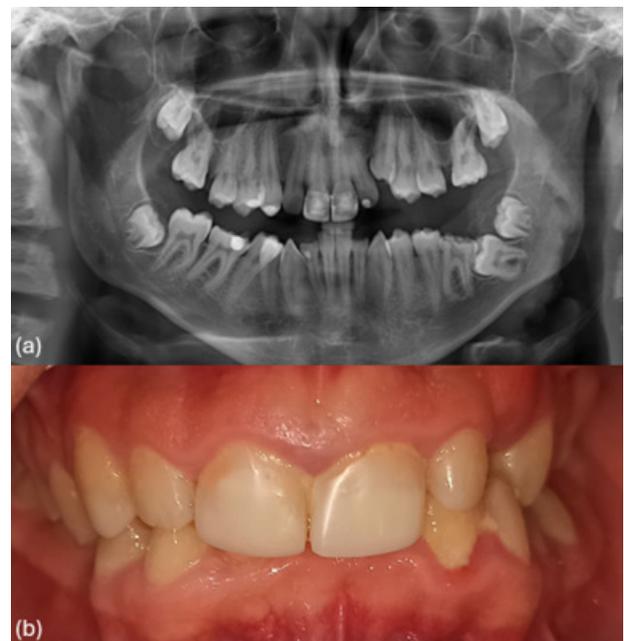


Figure 5. (a) Orthopantomogram taken in 2024, (b) Intraoral photograph taken in 2024

DISCUSSION

The management of dental treatment in patients with syphilis begins with diagnosis. Caution should be exercised to prevent the transmission of infection in patients undergoing treatment or those who still show positive serological test results post-treatment. Dental treatment can be initiated either in the absence of oral lesions or after successful disease treatment.⁷ In this particular case, since the patient had no oral syphilis lesions and the serological test was negative, dental treatment was immediately commenced.

The primary symptoms of congenital syphilis encompass interstitial keratitis, eighth nerve deafness, and Hutchinson's teeth - this is known as Hutchinson's triad.⁴ In the case discussed, symptoms such as interstitial keratitis and eighth nerve deafness were not observed. Hutchinson's incisors were clinically and radiographically identified in the patient's permanent incisors, whereas Mulberry molars were found in the primary and permanent molars. It is crucial to mention that the 11-year-old male patient had sought medical attention at the clinic 4 years earlier, but his symptoms remained undiagnosed. We determined a diagnosis of congenital syphilis based on the aforementioned findings.

Lauc *et al.*⁸ hypothesized that the enamel hypoplasia observed in congenital syphilis encompasses Fournier's canines. They also suggested that while Mulberry molars are common, they are not exclusive to congenital syphilis. Consequently, neither Fournier's canines nor Mulberry molars have been identified as pathognomonic for congenital syphilis.

The early loss of primary teeth associated with congenital syphilis has been documented.⁹ However, it is not possible to definitively ascertain whether the loss of primary teeth in this instance was due to congenital syphilis or prior dental caries.

Penicillin G can be used to treat all stages of syphilis. For early latent syphilis, benzathine penicillin G (2.4 million units, intramuscular, single dose) is recommended; for late latent syphilis, benzathine penicillin G (2.4 million units/week, intramuscular for 3 weeks) is suggested.⁶ The latter treatment protocol was initiated for an individual with late latent syphilis. The same protocol was also applied to their mother and sister, both diagnosed with syphilis.

There is limited literature on dental treatment for syphilis patients. In the few available studies, treatments vary based on the number of findings, severity, and time of diagnosis. Treatment options for permanent first molars with significant material loss can range from crowning to extraction, depending on the severity of the disease and the patient's overall oral health.¹⁰ In our case, we decided to extract the upper permanent first molars exhibiting with apical lesions and severe material loss. Furthermore, inadequate anterior restorations were replaced with strip crowns, some syphilitic teeth were abraded to improve their aesthetic appearance, and fluoride was applied to prevent sensitivity. Composite restorations in our patient were performed using the etch-bleach-seal technique with 37% phosphoric acid for 60 s, 5% sodium hypochlorite for 60 s, and then 37% phosphoric acid again for 30 s to enhance bonding to hypoplastic teeth. No treatment was applied to the lower anterior teeth due to their poor visibility in the mouth, and to avoid causing sensitivity and loss of tooth material. Oral hygiene recommendations were provided to the patient to help maintain oral health.

CONCLUSION

Upon reviewing the literature on syphilis, it is clear that recognizing the disease and administering timely, appropriate penicillin treatment is a highly effective way to reduce this infectious disease and prevent significant future morbidity. Dentists must possess the ability to recognize the intraoral manifestations of systemic diseases like syphilis, refer patients as appropriate, diagnose the disease, and initiate the appropriate treatment. In doing so, early diagnosis and treatment can forestall disease progression and spread.

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Case Report

Idiopathic Granulomatosis in Gingiva: A Challenging Case Report

Diş Etinde Saptanan İdiyopatik Granülomatozis: Zorlu bir Vaka Raporu

Deren Sezgin¹ , İpek Atak Seçen² , Ayşen Bodur³ , Benay Yıldırım⁴ 

ABSTRACT

Introduction: Identifying the etiology and pathogenesis of granulomas in the orofacial region can be challenging as a wide range of disorders are associated with granulomatosis. A diverse range of etiologies, including genetic, immunologic, allergic, and infectious mechanisms, have been implicated in granulomatosis. A comprehensive clinical, microscopic, and laboratory assessment may be necessary to ascertain the underlying cause of granulomatous inflammation.

Case Report: This case presents a female adolescent patient with idiopathic granulomatosis in the gingiva, lacking any identifiable causative factors. Intraoral examination revealed granular erythematous gingiva, especially in the anterior regions of the maxillary and mandibular arches, and a biopsy was taken after initial periodontal therapy. A histopathological examination revealed the presence of a non-caseating granulomatous lesion. Further investigations were conducted to rule out potential causative factors. Subsequent analysis showed no abnormalities in the patient's general health.

Conclusion: In the absence of a clear etiological explanation for a given lesion, eliminating the disease and constructing an appropriate treatment plan may prove challenging.

Keywords: Gingival swelling; Granulomatosis; Idiopathic; Inflammation

ÖZET

Giriş: Orofasial bölgedeki granümlerin etiyolojisini ve patogenezini belirlemek, çok çeşitli hastalıkların granülomatozis ile ilişkili olması nedeniyle zor olabilmektedir. Granülom oluşumunda; genetik, immünolojik, alerjik ve enfeksiyöz dahil olmak üzere çok sayıda etiyoloji öne sürülmüştür. Granülomatöz inflamasyonun altında yatan nedeni tespit etmek için kapsamlı bir klinik muayene ile birlikte, mikrobiyolojik değerlendirme ve laboratuvar değerlendirmeleri gerekebilir.

Vaka Raporu: Bu olgu raporunda, dişetinde idiyopatik granülomatozisi olan ve tanımlanabilir herhangi bir nedensel faktör bulunmayan adölesan dönemdeki kadın hasta sunulmaktadır. Ağız içi muayenede özellikle maksiller ve mandibular arkaların ön bölgelelerinde granüler eritematöz dişeti saptanmış ve başlangıç periodontal tedavisinden sonra ilgili bölgeden biyopsi alınmıştır. Histopatolojik incelemede, kazeifiye olmayan granülomatöz bir lezyonun varlığı tespit edilmiştir. Potansiyel etiyolojik faktörleri ekarte etmek için ilgili bölümlerde ileri tetkikler yapılmıştır. Devamında yapılan analizler hastanın sistemik durumunda herhangi bir anomali olmadığını göstermiştir.

Sonuç: Granülomatöz lezyonlar için net bir etiyolojik faktör saptanamadığında, hastalığı ortadan kaldırmak ve uygun bir tedavi planı oluşturmak zor olabilmektedir.

Anahtar Kelimeler: Gingival büyüme; Granülomatozis; İdiyopatik; İnflamasyon

Makale gönderiliş tarihi: 9.11.2024; Yayına kabul tarihi: 12.03.2025

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INTRODUCTION

Granulomatous inflammation is a delayed hypersensitivity reaction, known as type IV, that can occur in response to many viral and non-infectious triggers.¹ This inflammatory process can localize within the oral cavity or manifest as part of a systemic pathology. Granulomas are the most characteristic histopathological feature of this condition. They comprise CD4+ T lymphocytes surrounding an area of epithelioid histiocytes. In certain instances, central caseation may occur within these granulomas, leading to their designation as “caseous granulomas”.^{1,2} The development of epithelioid histiocytes and the subsequent formation of granulomas can occur due to many causes. Foreign body reactions to dental materials are commonly observed, especially in the oral region. Additionally, granulomas can develop due to infectious agents (such as bacteria or fungi) or indicate the systemic manifestation of several disorders in the oral cavity.² Recognizing that granulomatous inflammation may also result from allergic responses to food or pharmacological agents is crucial.³ Granulomatous lesions within the oral cavity without apparent cause pose considerable

diagnostic challenges. The following report details the clinical diagnosis and management of a 17-year-old female adolescent patient who presented at the periodontology clinic for a detailed investigation of gingival hyperplastic areas.

CASE REPORT

A 17-year-old female adolescent was referred to the Department of Periodontology with a chief complaint of difficulty in performing oral hygiene procedures, gingival swelling, and bleeding over the past six months. The patient reported no history of systemic disease, including family history or any medication, drug, or food allergies. She did not have any parafunctional habits. She had not undergone any surgical procedures. The patient reported that she brushed her teeth once a day and did not perform interdental cleaning. An extra-oral examination revealed no abnormalities on or around the lips. There was no paralysis of the facial muscles. Intraoral examination revealed an erythematous gingiva with a granular appearance, particularly in the anterior areas of the maxillary and mandibular arches (Fig.1A, Fig.1B).

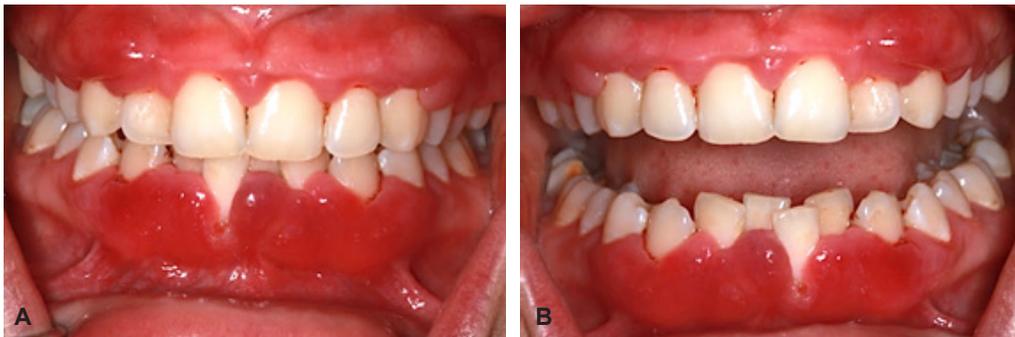


Figure 1A&1B. View of intraoral hyperplastic areas in the first visit.



Figure 2. Panoramic radiograph.

Table 1. Baseline periodontal parameters.

	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28	
Mobility		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Implant																	
Furcation																	
Bleeding on Probing		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Plaque	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Gingival Margin	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Probing Depth	3	2	2	2	1	1	2	2	4	4	5	5	4	3	3	1	3

Buccal

Palatal

Gingival Margin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Probing Depth	2	2	1	2	1	1	1	2	2	1	2	2	1	1	1	1
Plaque	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Bleeding on Probing	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Furcation																
Note																

Mean Probing Depth = **2 mm** Mean Attachment Level = **-1.6 mm** **48 %** Plaque **40 %** Bleeding on Probing

Lingual

Buccal

Gingival Margin	0	0	0	0	0	0	0	0	0	3	3	3	3	3	0	3
Probing Depth	3	3	2	2	1	2	2	2	1	1	1	1	1	1	1	1
Plaque	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Bleeding on Probing	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Furcation																
Implant																
Mobility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38

Table 2. Periodontal parameters at the reevaluation session.

	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28	
Mobility		0	0	0	0	0	0	0									
Implant																	
Furcation																	
Bleeding on Probing		■				■	■	■	■	■	■	■	■	■		■	
Plaque		■	■						■	■	■	■	■	■		■	
Gingival Margin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Probing Depth	3	2	2	2	1	1	2	2	2	2	4	4	4	5	4	3	3

	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28	
Gingival Margin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Probing Depth	2	2	1	2	1	2	1	1	2	2	2	1	1	2	2	1	1
Plaque	■	■	■	■					■	■	■	■	■	■		■	
Bleeding on Probing	■		■			■	■	■	■	■	■	■	■	■		■	
Furcation																	
Note																	

Mean Probing Depth = 2 mm Mean Attachment Level = -1.6 mm 37 % Plaque 37 % Bleeding on Probing

	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28
Note																
Furcation																
Bleeding on Probing	■	■	■	■					■	■	■	■	■	■		■
Plaque	■	■	■	■					■	■	■	■	■	■		■
Gingival Margin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Probing Depth	3	3	2	2	2	1	1	1	2	1	1	1	2	1	1	1

	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28
Gingival Margin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Probing Depth	3	3	2	2	2	1	1	1	2	1	1	1	2	1	2	3
Plaque	■	■	■	■					■	■	■	■	■	■		■
Bleeding on Probing	■	■	■	■					■	■	■	■	■	■		■
Furcation																
Implant																
Mobility		0	0	0	0	0	0	0								

48 47 46 45 44 43 42 41 31 32 33 34 35 36 37 38

There were no apparent changes in the tongue or other parts of the mucosa. The Modified Plaque Score (O'Leary, 1972) was 48%, with 40% bleeding on probing (Ainamo & Bay, 1975) and probing depths ≥ 4 mm due to pseudopockets, and clinical attachment loss on teeth number 12, 13 and 23 (Table 1). A radiographic examination was performed, which revealed evidence of bone loss in the maxillary anterior region (Fig. 2). As stated in the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions, the patient was diagnosed with localized periodontitis, Stage 2, Grade C.⁴ Treatment was initiated after obtaining the necessary consent from the patient. In the initial periodontal treatment, supra- and subgingival scaling was performed for all quadrants within one week. The patient was called for follow-up visits to evaluate plaque control at weeks 2 and 4. At the 3-month re-evaluation, no significant improvement was found in the pseudo-pocket areas (Table 2). In the surgical stage, firstly, surgical removal of the hyperplastic tissue in the lower anterior region was planned. In the surgical stage, under local anesthesia (articaine HCl), hyperplastic tissue was excised using a number 15 scalpel, and gingivoplasty was performed to adjust the contours of the area. Vestibuloplasty was performed to increase the depth of the vestibule in the region of teeth 31,41,42. The procedure was concluded with

suturing using a 4/0 resorbable multifilament suture (Fig. 3). The excised specimens were fixed in 10% buffered formalin and sent to the Department of Oral Pathology.

The histological examination revealed the presence of mononuclear inflammatory cells, and the formation of granulomas scattered inside the collagenized connective tissue underneath the keratinized, mature stratified squamous epithelium. Under high magnification, the granulomas were shown to be non-caseating granulomas consisting of epithelioid cells in the center, lymphocytes, and histiocytes in the surrounding area (Fig.4). Polarized light microscopy yielded negative results for foreign bodies, while Periodic Acid-Schiff (PAS) staining showed no evidence of *Candida* or other fungi. Furthermore, Ziehl-Neelsen staining did not reveal the presence of *Tuberculosis bacilli*.

A pediatrics consultation was sought to aid in diagnosing granulomatous diseases in the oral region. Additional tests, including a complete blood count, chest radiography, and abdominal ultrasound, were conducted to exclude potential causal factors. Subsequent examination indicated no abnormalities in the patient's overall health. The conclusive diagnosis, drawn from the existing evidence, was a non-specific granulomatous disease.



Figure 3. Post-operative view.

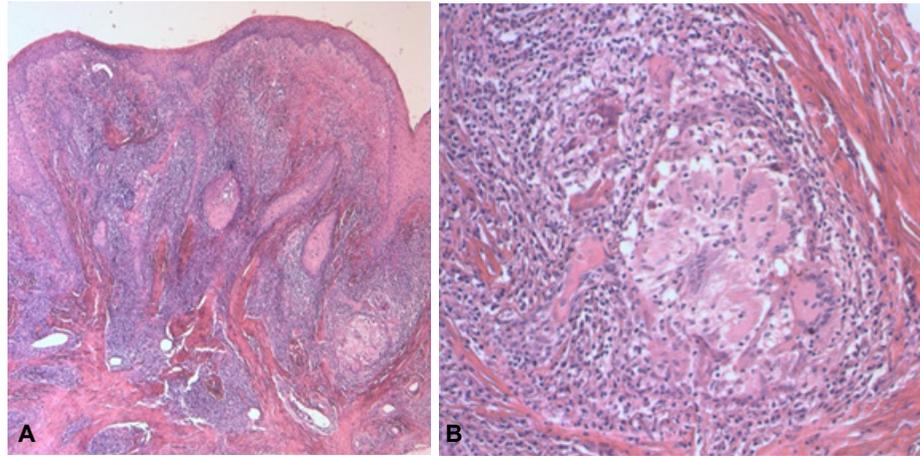


Figure 4. Histopathological characteristics of gingival tissue. **A.** Dense inflammation and granulomas in connective tissue beneath mature stratified squamous epithelium, $\times 40$ magnification, Hematoxylin & Eosin. **B.** High-magnification view of a non-caseating granuloma, $\times 200$ magnification, Hematoxylin & Eosin.

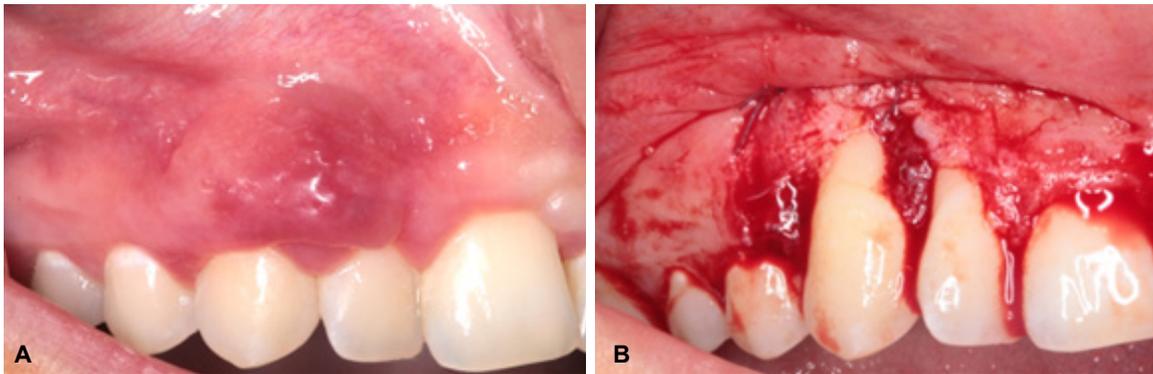


Figure 5. Removal of the second biopsy sample. **A.** View of the hyperplastic region with granular structure. **B.** Site view after the surgery.



Figure 6A & 6B & 6C. Intraoral view at the one-month follow-up visit after the second biopsy was taken.

In the course of a session conducted to examine the operative site, a decision was made to take a biopsy from the most affected area in the maxilla. The pathology result further supported the initial diagnosis (Fig. 5A, Fig. 5B). Despite the emphasis on the significance of regular periodontal follow-up sessions and the critical role of maintenance treatment, the patient could not be examined at the

planned intervals due to socioeconomic constraints. At the one-month follow-up visit following the second biopsy, the patient exhibited an inability to achieve plaque elimination. During the intraoral examination, oedematous areas were identified in the right maxillary canine and mandibular anterior region (Fig. 6A, Fig. 6B, Fig. 6C).

DISCUSSION

The etiologies of erythematous swellings in the gingival mucosa are diverse and may include a range of potential causes.^{4, 5} The underlying reason might exhibit significant variability and can provide significant challenges in diagnosis. Among the causes of gingival swelling, granulomatous inflammation is an uncommon reason. Granulomatous inflammation represents a specific form of chronic inflammation.⁶ Histopathologically, a granuloma is a distinct structure composed of epithelioid-shaped macrophages, multinucleated giant cells, lymphocytes, and fibroblasts.

Granulomatous inflammation has a multifactorial cause and may arise as a reaction to environmental or genetic factors or infectious organisms, or it may be idiopathic, for which there is no known trigger.⁷ The clinical findings associated with granulomatous inflammation are usually variable and often indistinct.⁸ It may manifest in the oral cavity, usually with various nonspecific clinical findings. The differential diagnosis includes foreign-body reaction, infectious disease, Crohn's Disease (CD), sarcoidosis, and Orofacial Granulomatosis (OFG).⁹ Foreign material, including dental materials and cosmetic fillers, is the most common source of oral granulomatous disorder.¹⁰ Foreign body reactions may develop as a potential consequence of dental materials, including suture material and prosthetic restoration.¹¹ At this juncture, the patient was queried about their dietary habits, including the consumption of specific foods and spices and the use of cosmetic and dental materials. Despite the change in materials, there was no regression of the lesions. However, as the patient's history did not include anything suggestive of a foreign body reaction, and she did not utilize any prosthetic restoration or intraoral device, a histological analysis ruled foreign body diagnosis out using polarized light microscopy.

In detecting a granuloma in the oral region, it is imperative to consider the possibility of OFG as a potential underlying condition. OFG is a rare condition increasingly recognized by the general medically literate public.⁵ No reliable epidemiologic data are available because most case series report small single-center groups of patients.¹² Subepithelial non-caseating granulomas histopathologically

characterize it and have a spectrum of possible clinical manifestations ranging from subtle oral mucosal swelling to permanent disfiguring fibrous swelling of the lips and face. Painful oral ulceration and neurologic manifestations in the head and neck region can also occur.⁴ In this case, OFG was not considered in the final diagnosis due to the absence of extraoral swelling, particularly in the lips, accompanying OFG, and the lack of facial paralysis.

Crohn's disease (CD) is defined as a chronic granulomatous condition that has the potential to affect any portion of the gastrointestinal tract, including the oral cavity. The clinical presentations of the disease may be highly variable. Up to 60% of patients present with oral lesions, which may be the initial sign of the disease in 5% to 10% of cases. Some studies have indicated a correlation between an earlier onset of the disease and the increased prevalence of oral signs. Abdominal ultrasound was obtained to rule out CD in the differential diagnosis, which was normal. Nevertheless, it is imperative to conduct periodic follow-ups on the case, as CD may still present at a later age.¹³

Sarcoidosis represents a relatively common multisystem disease with an unknown etiology. Several studies suggest that host and environmental factors are essential in developing the disease.¹⁴ While the specific environmental factors or infectious agents that contribute to the development of sarcoidosis remain to be identified, numerous studies have documented the spatial, seasonal, and occupational clustering of sarcoidosis cases. As no specific tests are currently available that can accurately diagnose the disease, sarcoidosis is most frequently diagnosed based on excluding other possible aetiologies. A diagnosis of sarcoidosis can only be made if there is evidence of microscopic granulomatous inflammation. To identify any pulmonary involvement and bilateral hilar lymphadenopathy, chest radiographs are usually employed.¹⁵ In our case, a chest radiography ruled out the diagnosis of sarcoidosis.

If an oral cause for the formation of the granuloma cannot be identified, it is crucial to thoroughly assess systemic factors that could contribute to the development of the granuloma using complete clinical, pathological, and laboratory tests. Once

the cause is correctly identified, the prognosis for the condition is significantly improved.⁸ In this particular case, after performing several diagnostic procedures including blood tests, chest radiography, and abdominal ultrasound, no conclusive results were obtained to provide clarity on the potential diagnosis for the formation of granulomas. In this case, generalized hyperplastic areas, as identified through clinical examination, and the absence of systemic findings suggested an idiopathic etiology.

The management of granulomatous lesions depends on the underlying etiology.² While various pharmacotherapies, such as topical and intralesional corticosteroid injections and systemic immunosuppressants, are recommended for treatment, it is essential to identify and address the etiological factor. The choice among these different therapies and agents was based on the patient's systemic conditions, preference, and the expertise/experience of the attending clinician.¹⁶ In this case, the absence of knowledge regarding the etiology limited our ability to plan an effective treatment strategy; therefore, regular follow-ups were planned.

The existing literature does not guide the appropriate length of follow-up for cases when idiopathic granulomatous lesions are present. The literature recommends regular follow-up cases with idiopathic granulomas, particularly in young patients, since Crohn's disease may develop symptoms over time.¹³ Given the patient's age and the absence of a definitive diagnosis, a comprehensive follow-up strategy, including frequent periodontal control and, if required, further periodontal treatments was deemed appropriate.

CONCLUSION

While it is uncommon, it is advisable to consider granulomatous disease as a possible diagnosis when encountering gingival hyperplasia in the oral region. A comprehensive clinical evaluation, a meticulous anamnesis, scheduled maintenance procedures and periodontal treatment aimed at eliminating biofilm, in conjunction with histopathological examinations are imperative for an accurate diagnosis.

ACKNOWLEDGMENTS

The authors would like to thank Gazi University Academic Writing Application and Research Center for proofreading the article.

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Multidisciplinary Rehabilitation of Ectodermal Dysplasia Using 3D-Printed Crowns and Conventional Removable Dentures: A Case Report

Ektodermal Displazinin 3D Baskı Kronlar ve Geleneksel Hareketli Protezler Kullanılarak Multidisipliner Rehabilitasyonu: Bir Olgu Sunumu

Elif Su Çiçek¹, Nilay Bozdoğan², Nagehan Aktaş³, Merve Bankoğlu Güngör⁴

ABSTRACT

Introduction: Ectodermal dysplasia is a rare hereditary condition characterized by developmental defects in ectodermal-derived tissues and organs. In cases of ectodermal dysplasia, missing teeth (anodontia, hypodontia), conically shaped teeth, inadequate development of the alveolar crests, and loss of vertical dimension are observed. Due to the lack of most primary and permanent teeth during childhood, the esthetic and chewing functions of these patients need to be restored with a multidisciplinary treatment approach in the early period. This case report describes the rehabilitation of a child patient with ectodermal dysplasia using three-dimensional (3D) printed crown prostheses for existing upper central teeth and removable prostheses for additional missing teeth.

Case Report: The treatment of a 10-year-old child patient who applied to Gazi University, Faculty of Dentistry, due to missing teeth was carried out and completed jointly by the Departments of Pediatric Dentistry and Prosthodontics. The extraoral examination of the patient, who was diagnosed with ectodermal dysplasia, revealed sparse eyebrows, hair, and eyelashes, dry and thin skin, and sagging and swollen lips. Intraoral examination identified only two conical-shaped maxillary central teeth. All procedures to be performed were explained to the patient and their parents, and their consent was obtained. As a result of the prosthetic analysis, it was decided to make a crown restoration for the existing teeth and an upper and lower removable prosthesis for the missing teeth. After tooth preparations, permanent resin crowns were fabricated using 3D printing technology and cemented onto the prepared teeth. The removable prostheses for the upper and lower jaws were completed using traditional methods and delivered to the patient, who was scheduled for follow-up appointments.

Conclusion: Early multidisciplinary intervention is crucial for patients with ectodermal dysplasia starting from childhood due to significant tooth loss, aiming to restore both esthetics and functionality. The goal in designing prostheses is to preserve existing teeth, esthetically restore conical-shaped teeth, and prevent resorption of the alveolar ridges. The application of 3D printing in pediatric dentistry holds substantial potential, offering an aesthetically pleasing, durable, and cost-effective alternative for prosthetic restorations in child patients with ectodermal dysplasia.

Keywords: 3D printing; Additive manufacturing; Ectodermal dysplasia; Pediatric dentistry; Prosthetic rehabilitation

ÖZET

Giriş: Ektodermal displazi, ektodermal kaynaklı doku ve organların gelişimsel kusurları ile karakterize nadir bir kalıtsal durumdur. Ektodermal displazi vakalarında eksik dişler (anodonti, hipodonti), konik biçimli dişler, alveolar kreterin yetersiz gelişimi ve dikey boyut kaybı gözlenir. Çocukluk döneminde birincil ve kalıcı dişlerin çoğunun eksik olması nedeniyle, bu hastaların estetik ve çiğneme fonksiyonlarının erken dönemde multidisipliner bir tedavi yaklaşımı ile restore edilmesi gerekmektedir. Bu olgu sunumu, ektodermal displazili bir çocuk hastanın mevcut üst santral dişleri için üç boyutlu (3B) baskı kronlar ve eksik dişler için hareketli protezler kullanılarak rehabilitasyonunu anlatmaktadır.

Vaka Raporu: Gazi Üniversitesi Diş Hekimliği Fakültesi'ne eksik dişler nedeniyle başvuran 10 yaşındaki bir çocuk hastanın tedavisi, Çocuk Diş Hekimliği ve Protetik Diş Tedavisi Anabilim Dalları tarafından birlikte gerçekleştirilmiş ve tamamlanmıştır. Ektodermal displazi tanısı konan hastanın ekstraoral muayenesinde seyrek kaşlar, saç ve kirpikler, kuru ve ince cilt, sarkık ve şiş dudaklar gözlenmiştir. İntraoral muayenede yalnızca iki konik biçimli maksiller santral diş tespit edilmiştir. Yapılacak tüm işlemler hasta ve ailesine açıklanmış ve onayları alınmıştır. Protetik analiz sonucunda mevcut dişler için kron restorasyonu ve eksik dişler için üst ve alt hareketli protez yapılmasına karar verilmiştir. Diş preparasyonunun ardından, 3D baskı teknolojisi kullanılarak daimi rezin kronlar üretilmiş ve prepare edilmiş dişlere simante edilmiştir. Üst ve alt çeneler için hareketli protezler geleneksel yöntemler kullanılarak tamamlanmış ve hastaya teslim edilmiştir; hastaya takip randevuları planlanmıştır.

Sonuç: Çocukluk döneminden itibaren ciddi diş kaybı olan Ektodermal displazi hastalarında, estetik ve fonksiyonelliği geri kazandırmayı amaçlayan erken multidisipliner müdahale çok önemlidir. Protezlerin tasarımındaki amaç, mevcut dişleri korumak, konik biçimli dişleri estetik olarak restore etmek ve alveolar kreterin rezorpsiyonunu önlemektir. Çocuk diş hekimliği alanında 3D baskı uygulaması, Ektodermal displazili çocuk hastalar için estetik açıdan tatmin edici, dayanıklı ve maliyet etkin bir alternatif sunan büyük bir potansiyele sahiptir.

Anahtar Kelimeler: 3D baskı; Çocuk diş hekimliği; Eklemeli imalat; Ektodermal Displazi; Protetik rehabilitasyon

Makale gönderiliş tarihi: 17.07.2024; Yayına kabul tarihi: 19.03.2025

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INTRODUCTION

Ectodermal Dysplasias (EDs) are a varied group of congenital disorders characterized by anomalies in at least two ectodermal appendages, such as hair, teeth, nails, or sweat glands. Typical manifestations include abnormal hair growth (hypotrichosis), dental anomalies, dystrophic nails (onychodysplasia), and functional defects in the sweat glands (hypohidrosis or anhidrosis). The estimated incidence is 1 in 100,000 births, but this rate may vary and may be higher in certain populations. EDs present a wide array of inheritance patterns, which can include autosomal dominant, autosomal recessive, and X-linked dominant or recessive forms. These disorders can also occur sporadically due to mutations during intrauterine development, resulting in a wide range of clinical presentations.¹⁻³

Ectodermal dysplasia is mainly classified into two types: Hypohidrotic/Anhidrotic ED and Hidrotic ED. The dentition and hair are similarly affected in both types of ED.^{1,3} Dental anomalies are observed in 79% of individuals with ED, affecting both primary and permanent dentition.^{4,5} The most common dental findings in individuals with ED include anodontia, oligodontia or hypodontia, tooth size and shape abnormalities, mineralized tissue defects, and tooth eruption issues.^{6,7} The absence of primary and/or permanent teeth is the most frequently reported oral manifestation amongst these individuals. Hypodontia is prevalent, with tooth agenesis generally observed more frequently in lower jaw.⁶ Shape deviations such as small size are also common. Incisors and canines often exhibit a conical shape, commonly described as "peg-shaped". Second molars typically exhibit taurodontism due to the Hertwig's epithelial sheath, which is of ectodermal origin, determining the root bifurcation site.^{6,7}

In addition to oral manifestations, individuals with ED exhibit a generalized symmetric reduction of the craniofacial complex.⁸ Dental agenesis and its impact on the growth and development of the jaws are significant clinical manifestations of ED. Maxillofacial growth is affected due to the absence of teeth, leading to craniofacial skeletal discrepancies. In sections without teeth, the alveolar edges display underdevelopment. Consequently, alveolar bone is thinner and less in volume compared to the alveoli

surrounding the existing teeth. Insufficient height of the alveolar edges leads to a decrease in lower face height, thereby reducing the vertical dimension of occlusion.^{7,9}

Recent advancements in three-dimensional (3D) printing technology have significantly expanded its applications in pediatric dentistry. In addition to its use in crown restorations, 3D printing has been employed in the fabrication of space maintainers, removable and fixed prostheses, and surgical guides, offering a more precise and patient-friendly approach. Compared to traditional methods, 3D-printed prostheses provide enhanced esthetics, better adaptation, and reduced treatment time, which is particularly beneficial in pediatric patients who may have limited tolerance for lengthy procedures. The ability to digitally design and rapidly manufacture customized prosthetic solutions makes 3D printing an increasingly viable option in modern pediatric dental care.¹⁰

Early prosthetic oral rehabilitation is recommended for these individuals to enhance orofacial development, restore functions such as chewing, swallowing, and phonetics, promote esthetics and psychological well-being, and minimize the impact on their quality of life. The rehabilitation treatment options for individuals with ED can vary widely and a multidisciplinary team approach is essential to the successful management of ED. This case report aimed to describe the rehabilitation of a child patient with ectodermal dysplasia using 3D printed crown prostheses for existing upper central teeth and removable prostheses for the additional missing teeth.

CASE REPORT

A 10-year-old male with Hidrotic Ectodermal Dysplasia was referred to the Gazi University, Faculty of Dentistry, Department of Pediatric Dentistry, for an examination due to the non-eruption of his permanent teeth. Extraoral examination revealed the characteristic features of ED, including brittle and fine blonde hair, narrow eyebrows and eyelashes, a depressed nasal bridge, a prominent forehead, peri-orbital and perioral pigmentation, protuberant lips, and an aged appearance (Figure 1).

An intraoral examination revealed the presence of only cone-shaped maxillary central incisors, with an-



Figure 1. Extra-oral view of the patient.

odontia in the mandible, low alveolar ridges, a loss of vertical dimension, and a reduced sulcus depth in the posterior region of the maxilla and mandible (Figure 2A, 2B). The radiographic examination confirmed the mandibular anodontia and the absence of all maxillary teeth except for two permanent maxil-

lary teeth (Figure 2C).

The treatment plan included maintaining oral hygiene, crown restoration of the existing teeth, and fabricating maxillary and mandibular removable prostheses for the missing teeth. A consent form was signed by the parent of the patient.

After the permanent maxillary central teeth were prepared, impressions were made using an irreversible hydrocolloid (Tropicalgin; Zhermack, Badia Polesine, Italy) (Figure 3A). Following the fabrication of custom trays, border molding was established, and final impressions were made using a zinc oxide-eugenol impression paste (Cavex Outline; Cavex Holland BV, Haarlem, The Netherlands) material. Gypsum models were subsequently produced, and custom bases of acrylic resin were prepared. Finally, both the occlusal vertical dimension and the occlusal relationship were recorded.

Digital impressions were obtained from the plaster models of the maxilla and mandible using an intra-oral optical scanner (Trios5, 3Shape, Denmark).

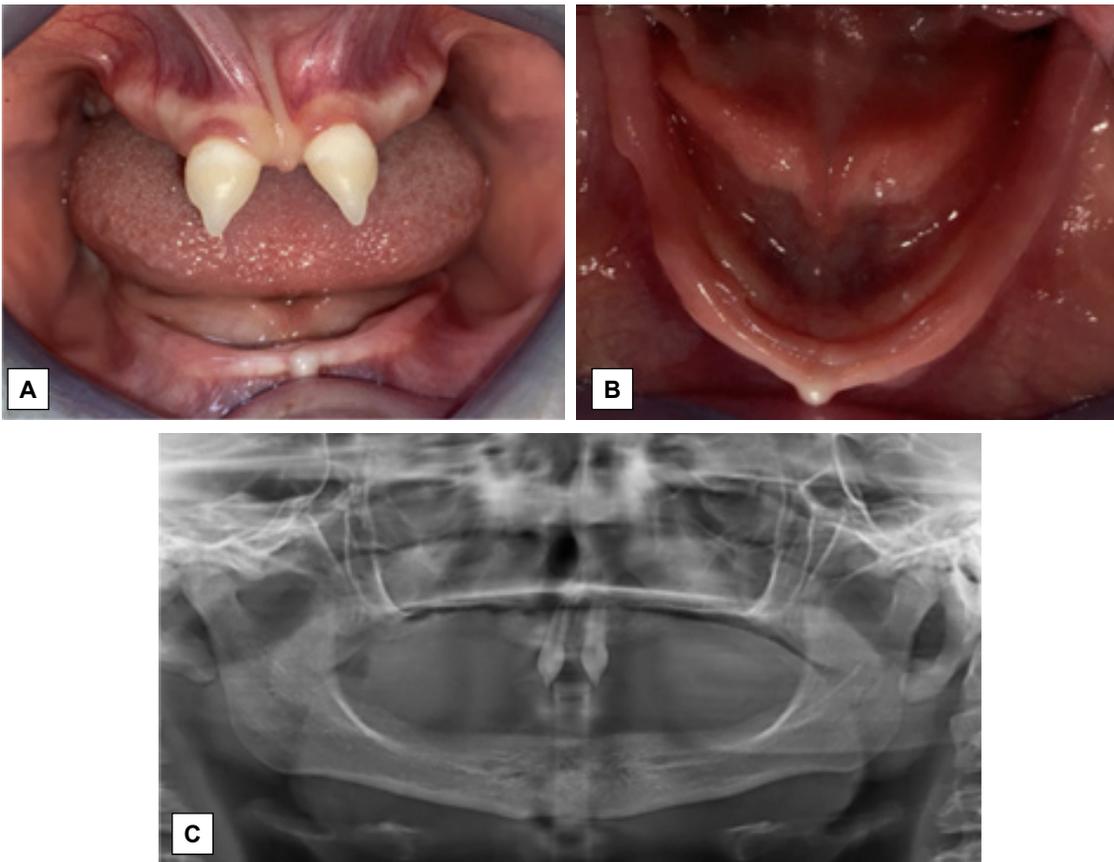


Figure 2. A) Intraoral preoperative view of the maxilla, B) Intraoral preoperative view of the mandible, C) Panoramic radiograph

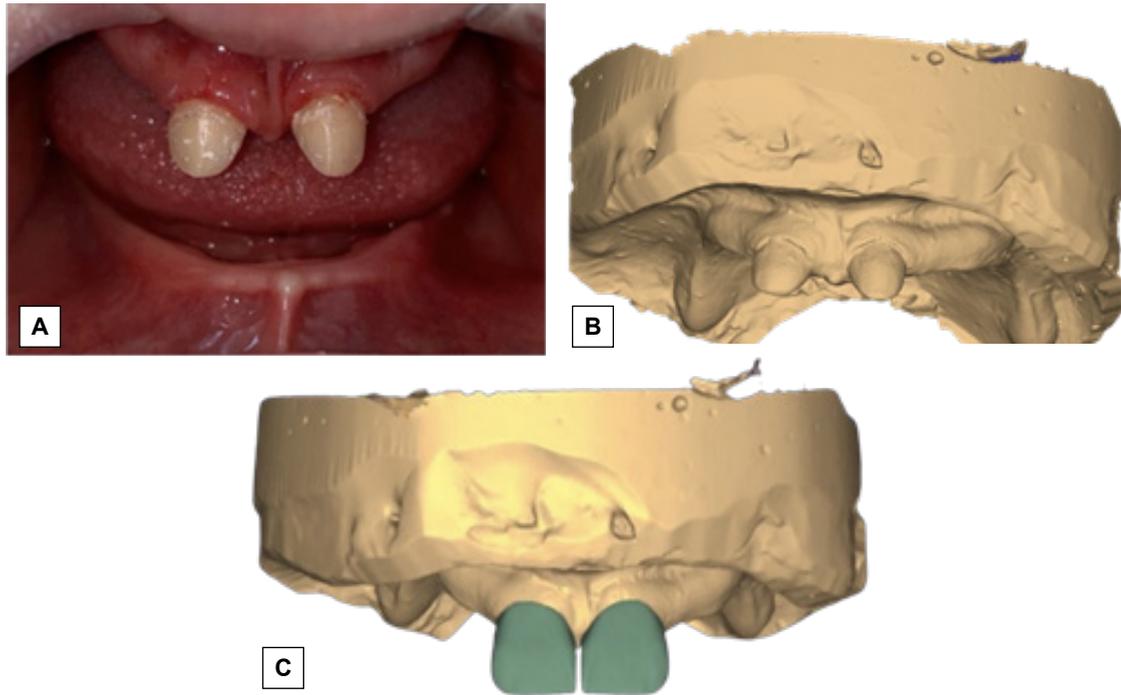


Figure 3. A) Preparation of cone-shaped maxillary central incisors, B) The digital impression of the prepared tooth, C) Crowns designed using software program

Afterward, these impressions were digitized to create virtual models (Figure 3B). Then, CAD software (exocad GmbH, Darmstadt, Germany) was used to design the crowns on the virtual model (Figure 3C). Following this, the crown designs were converted to the Standard Triangulation Language (STL) file format to allow for 3D printing, and the file was consequently sent to a laboratory to construct restorations via a 3D printer. Moreover, the STL file was incorporated into the PreForm software (Formlabs Inc., Somerville, MA, ABD) to automate the construction of the support structures. Ultimately, the crowns were printed using Permanent Crown Resin (Formlabs Inc) on a 3D printer (Formlabs Form 3B, Formlabs Inc).

The crowns were cleaned in the printer's washing unit (FormWash; Formlabs Inc) using isopropyl alcohol for 3 minutes after fabrication. Subsequently, they were subjected to a polymerization phase in the printer's curing unit (FormCure; Formlabs Inc). The structural supports were removed post-polymerization. An additional post-polymerization stage was carried out, involving a 20-min exposure at 60 °C within the same curing device. Surface finishing was performed according to the manufacturer's recom-

mendations.

The tooth surface was prepared for cementation by applying a bonding agent (Scotchbond Universal Plus, 3M ESPE) and then air-drying. The inner surface of the restoration was prepared in accordance with the manufacturer's guidelines. Before cementation, the crowns were sandblasted with 50 μm Al_2O_3 particles for 20 s and then cleaned using an ultrasonic cleaner. The finished crowns were then silanized (G-Multi Primer; GC, Tokyo, Japan) and cemented using adhesive resin cement (G-CEM ONE; GC) (Figure 4).



Figure 4. Cementation of 3D-printed crowns



Figure 5. A) Wax try-in, B) Fabricated maxillary and mandibular removable prostheses

The arranged teeth were verified in the mouth during the wax try-in appointment (Figure 5A). After assessing occlusion, esthetics, and phonetics, the dentures were fabricated from acrylic resin (Figure 5B). After laboratory processing, the prostheses were placed in the patient's mouth, and necessary adjustments were made. Then, a direct polysiloxane

soft liner (Mollosil Plus, Detax, Ettlingen, Germany) was used to improve the fit and comfort of the prosthetics. The removable prostheses were then delivered to the patient (Figure 6). Follow-up visits were scheduled at 6-month intervals to adjust the dentures, evaluate growth and development, and monitor oral hygiene.

DISCUSSION

In this case report, the rehabilitation of a child with ED using 3D-printed crowns for the existing upper central teeth and removable prostheses for the additional missing teeth was presented.

The management of EDs often necessitates a multidisciplinary approach to address the various symptoms and complications, ensuring the maintenance of dental health. Restoring oral function and esthetics is critical for these patients, as it significantly impacts their psychological well-being. Comprehensive oral rehabilitation for these patients is essential from functional, physiological, and psychosocial perspectives.¹ The treatment should be planned by a team of specialists, including particularly pediatric dentists and prosthodontists.² Treating these patients involves several key points as growth and development (understanding the growth patterns and developmental milestones of pediatric patients), behavioral management (employing strategies to manage and support the behavior of young patients in a dental visit), prosthesis fabrication techniques (skills in creating prosthetic devices suitable for children), restorative techniques (modifying existing teeth using various



Figure 6. Postoperative extra-oral view of the patient.

restorative methods), motivating patients and parents (encouraging both the child and their caregivers to use and care for the prosthesis effectively), and long-term follow-up (providing ongoing care, including adjustments or replacements of the prosthesis as the child grows).¹¹

Prosthetic rehabilitation at an early age for pediatric patients with ED offers several advantages, including improved oral functions (chewing and speech), physiological benefits (self-esteem and social interactions), facilitated facial development (jaw growth and facial symmetry), prevention of oral issues (avoiding malocclusions and maintaining space), better adaptation to prostheses (ease of adjustment and habit formation), and improved quality of life (daily activities and overall well-being).^{1,11-20} It is recommended that children with EDs use a dental prosthesis before they start school, typically around ages 3-4. Similarly, Schnabl *et al.*¹² stated that the median age for prosthetic treatment of ED patients was 4 years. In the presented case report, the child was 10 years old and had not previously worn prostheses, indicating a relatively late treatment age.

The prosthetic rehabilitation of a patient with ED can involve the use of fixed or removable prostheses; however, each option requires specific considerations. Fixed partial dentures are less commonly used in the ED treatment due to the limited number of teeth. Fixed prostheses with rigid connectors can also hinder natural jaw development and cause further complications.^{13,14} The most preferred method of treatment is using removable prostheses.¹ These prostheses can be adjusted and replaced according to growth.¹¹ However, clinicians may face some challenges. ED affects both primary and permanent teeth, usually resulting in conical or peg-shaped teeth.¹⁴ Due to the absence of teeth, the alveolar ridges often remain underdeveloped, complicating denture fitting, retention, and stability. Ensuring dentures remain stable and function properly with less bone support is more challenging.¹⁶

Furthermore, children are continuously growing, necessitating frequent adjustments and replacements of dentures to accommodate changes in the alveolar bone and facial structure.¹⁶ The knife-edge morphology of the alveolar ridges, coupled with decreased

alveolar bone height, is a common observation.¹ Underdeveloped alveolar ridges and dry oral mucosa can compromise the retention and stability of prostheses. Frequent denture relining or replacement is necessary due to changes in the vertical dimension of occlusion and mandibular posture.¹⁷ Bone augmentation procedures are not suitable for pediatric patients; therefore, soft liners can be used to improve the fit and comfort of the prosthetics.^{16,17}

Successful treatments of children with ED were presented as case reports.^{1,2,18-20} Abdulla *et al.*¹ presented the prosthetic treatment of a young boy with ED. In the treatment plan, the patient's conical maxillary anterior teeth were restored using composite strip crowns, and then removable partial dentures were delivered, and satisfactory results were obtained. Bolaca *et al.*² presented two cases with ED. In the first one, the child had two cone-shaped central incisors, and a maxillary overdenture and a mandibular complete denture were fabricated for the patients. The second patient was treated with maxillary and mandibular removable partial dentures. Both prosthetic treatments were reported as successful, resulting in significant enhancements in aesthetic outcome, speech, and mastication. These advancements were critical in dental prosthetic treatments, significantly improving the children's quality of life.

Török *et al.*¹⁸ reported a prosthetic treatment of a 16-year-old boy with ectrodactyly-ectodermal dysplasia-cleft lip/palate syndrome (EEC). In this case, a telescopic retained overdenture was fabricated for the mandible. Impression was taken with an intra-oral scanner, and the telescopes were digitally designed. Selective laser sintering was then used to fabricate the primary and secondary telescopes. The combination of digital and traditional prosthetic methods resulted in an exceptionally effective overdenture.

Seremidi *et al.*¹⁹ reported three clinical cases with a 2-year follow-up. The children were very young (3.5 years old), and exhibited severe oligodontia due to ED. The cases were treated with interim removable dentures to replace missing teeth, restore vertical dimension, and enhance function and esthetics. Two years post-treatment, patients and parents reported excellent adaptation to the prostheses and high satisfaction with esthetics. Montanari *et al.*³ conducted a

retrospective cohort study to assess skeletal growth, implant, and prosthetic survival rates, as well as success rates, and possible complications following a rehabilitation procedure involving a maxillary denture and an implant-supported overdenture attached by a sliding bar in ED patients. Over 7 years, nine patients received conventional dentures, followed by a maxillary denture and an implant-supported overdenture with a sliding bar connected to two implants in the anterior mandible. These patients were monitored for 3 to 12 years. The study concluded that mandibular growth near implant sites continues following their placement. Moreover, the implants provided effective support for prostheses in preteen patients with ED, demonstrating high success and survival rates with minimal complications. In patients with ED, the use of implant-supported prostheses is relatively rare, but they are still utilized. Sun *et al.*²⁰ documented the treatment of a 16-year-old patient with ED who had severe hypodontia, maxillary retusion, and a thin knife-edge alveolar crest. The treatment involved distraction osteogenesis, a bone graft from the iliac crest, implant placement, and fabricating implant-supported overdentures. Despite requiring an additional implant during the 10-year follow-up, the treatment plan achieved a satisfactory outcome for the patient.

In the present case report, the remaining central teeth were restored with separated 3D-printed crowns. The crowns were not splinted to allow for natural jaw development. The use of 3D-printed resin crowns was selected for several reasons, including their precise customization for a perfect fit and improved comfort, quick production for time-efficient treatment, reduced cost, minimally invasive preparation procedure, and natural aesthetics to boost the child's smile and confidence.

In this case, the other missing teeth were restored with removable prostheses. Given the patient's age, a conservative treatment plan was preferred. To avoid possible trauma on the alveolar ridges, the mucosal sides of the prostheses were relined by using a soft denture liner. The patient was satisfied with the prostheses, and he expressed that he could comfortably use them. This treatment approach notably responded to the distinct needs of pediatric patients with ED, promoting both oral health and overall well-being. Due to the growth of

alveolar ridges, prostheses may need modifications every 2 to 3 years, requiring relining or fabrication of new prostheses as necessary. Regular relining and rebasing of prosthetics should not discourage clinicians from intervening early in children's dental care. These procedures enable the child to develop normal speech, chewing, and swallowing functions, maintain proper facial support, and enhance temporomandibular joint function.¹⁶ Thus, the patient has been scheduled for a follow-up every six months.

CONCLUSION

In managing prosthodontic rehabilitation for pediatric patients with ED, the choice of prosthesis depends on the individual's needs and anatomical considerations of the patient. Typically, removable prosthodontics are the most suitable option for growing children, while 3D-printed crowns can be viable alternatives to conventional treatments. Treating pediatric ED patients with fixed or removable prostheses not only improves their oral function and esthetics but also significantly enhances their psychological and social well-being. Regular clinical follow-ups and a personalized treatment approach are crucial to ensuring the best possible outcomes for these pediatric patients.

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