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YAZIM KURALLARI

Derginin yayın dili Ocak 2024 tarihinden itibaren İngilizcedir.

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 ORİJİNAL 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 raporunun sisteme pdf dosyası olarak yüklenmesi gerekmektedir.**

Değerlendirme Süreci

ADO Klinik Bilimler Dergisi, değerlendirme süreci boyunca hem hakemin hem de yazarın kimliklerinin birbirinden gizlendiği anlamına gelen çift-kör değerlendirme sürecini kullanır. Bu nedenle yazarların makale dosyalarının kimliklerini açığa çıkarmayacak şekilde hazırlamaları gerekmektedir. Editörler hakemleri derginin online sistemi üzerinden davet edecek, hakemlerin kabulü sonrasında değerlendirme süreci başlayacaktır. Hakemler dergi sistemine giriş yaparak ilgili dosyaların indirilmesi ve öneri süreci davetini kabul ederler. İncelemeler için izin verilen süre: 4 hafta olup, editöryal süreç gerektiği takdirde değiştirilebilir.

KABUL EDİLEN MAKALE TÜRLERİ

Orijinal araştırma makalesi: Başlıklar, Özet (İngilizce ve Türkçe), Giriş, Gereç ve Yöntemler, 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

Teknik not: Başlık, Özet, Giriş, Sonuçlar, Kaynaklar, Tablolar, Şekiller ve Şekil açıklamaları (gerekli ise)

Editöre Mektup: Başlık, Özet, Giriş, Sonuçlar, Kaynaklar, Tablolar, Şekiller ve Şekil açıklamaları (gerekli ise)

MAKALE HAZIRLAMA

a- Her yazı normal ve düz yazı tipinde (12 punto Times New Roman), 1,5 satır aralıkla iki yana dayalı olarak yazılmalı ve tüm sayfalar orta alttan art arda numaralandırılmalıdır.

b- Her paragrafta satır girintisi kullanılmalıdır.

c- Latince terimler veya tür adlarında italik karakterler kullanılmalıdır. (örn. in vitro, Staphylococcus aureus).

d- Birimler ve kısaltmalarda, uygun olduğu durumlarda Uluslararası Birimler Sistemi (SI: http://www.bipm.org/en/si/) kullanılmalıdır. Yaygın olarak kullanılan birimler için kısaltma örnekleri şunlardır: yıl-y, hafta-hf, saat-sa., dakika-dk., saniye-sn., gram-g, litre-L, mikrolitre-µL, metre-m, Celsius derece-°C vb. Türkçe kısaltmalar dizini için Türk Dil Kurumu'nun internet sitesine bakmalıdır. (TDK; http://www.tdk.gov.tr).

e- Ondalık sayılarda ayırıcı olarak nokta (.) kullanılmalıdır ve rakam ile birim arasında boşluk bırakılmalıdır. (örn. 12.3 mm, 37 °C) Yüzde değeri verirken değer ile yüzde işareti arasına boşluk bırakılmamalıdır (örn. %0.2).

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.

g-Çalışmada kullanılan malzeme/ekipmanın kaynağı ilk bahsedildiğinde belirtilmelidir (isim, üretici, şehir, eyalet (varsa), parantez içinde ülke). Aynı ürüne ilişkin daha sonraki alıntılarda menşei belirtmeye gerek yoktur. Daha önce belirttiğiniz firmanın ürettiği başka bir üründen bahsederken sadece firmayı belirtmeniz yeterlidir.

BAŞLIK SAYFASI

Başlık sayfası aşağıdakilerden oluşmalıdır:

a- Makalenin başlığı (İngilizce ve Türkçe)

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.

d- Tüm yazarların ORCID tanımlayıcıları. Bir tane almalı veya https://orcid.org/ adresinden kendinizinkini kontrol etmelisiniz.

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.

ÖZET ve ANAHTAR KELİMELER:

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 YÖNTEMLER

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 alıntıların 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 iletişimler referans olarak kabul edilmez.

Metinde alıntı yapma örnekleri:

…önceki bir çalışmada belirtildi.[1]

…önceki çalışmalarda belirtildi.[2,4-6,8]

Yılmaz[9] tarafından yakın zamanda yapılan bir araştırmada şöyle bildirildi:

Yılmaz ve Akın tarafından yakın zamanda yapılan bir çalışmada[10] şu rapor edildi:

Yılmaz ve ark.[11] tarafından yakın zamanda yapılan bir çalışmada şu rapor edilmiştir:

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 büyütme 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 8'i 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.

INSTRUCTIONS FOR AUTHORS

The publication language of the journal has been English since January 2024. Authors are required to declare that the submitted manuscript has not been previously published, accepted for publication, or submitted for evaluation in any other journal. Abstracts presented at any scientific meeting or congress must be clearly stated at the time of submission. Authors assume full responsibility for the manuscript throughout the submission and peer-review process. ORIGINAL RESEARCH ARTICLES requiring an ethical statement but lacking the name of the Ethics Committee/Institution, approval date, and approval number will not be considered for evaluation. Authors must state that signed informed consent was obtained for all case reports and all studies requiring informed consent. Informed consent forms must be uploaded to the system separately as PDF files. Ethical declarations should be provided in the Materials and Methods section together with the name of the Ethics Committee, approval date, and approval number, and must also be uploaded to the system separately

as PDF files. **For each submitted manuscript, the similarity report, must be uploaded to the system as a PDF file.**

Review Process

ADO Journal of Clinical Sciences employs a double-blind peer-review process, in which both the reviewers' and authors' identities are concealed throughout the evaluation process. Therefore, authors are required to prepare their manuscripts in a manner that does not reveal their identities. Editors invite reviewers through the journal's online submission system, and the review process begins upon acceptance of the invitation by the reviewers. Reviewers access the journal system to download the relevant files and accept the invitation to participate in the review process. The standard review period is 4 weeks; however, this duration may be modified by the editorial office when necessary.

ACCEPTED MANUSCRIPT TYPES

Original Research Article: Sections should include: Title, Abstract (English and Turkish), Introduction, Materials and Methods, Results, Discussion, Conclusion, Acknowledgements, References, Tables, Figures, and Figure Legends.

Case Report: Sections should include: Title (full and short title), Abstract (English and Turkish), Introduction, Case Report, Discussion, Conclusion, Acknowledgements, References, Tables, Figures, and Figure Legends.

Technical Note: Sections should include: Title, Abstract, Introduction, Results, References, Tables, Figures, and Figure Legends (if required).

Letter to the Editor: Sections should include: Title, Abstract, Introduction, Results, References, Tables, Figures, and Figure Legends (if required).

MANUSCRIPT PREPARATION

a) All manuscripts should be prepared in plain text format using 12-point Times New Roman font, with 1.5 line spacing and justified alignment. All pages should be numbered consecutively at the bottom center.

b) A first-line indentation should be used for each paragraph.

c) Italic characters should be used for Latin terms and species names (e.g., *in vitro, Staphylococcus aureus*).

d) The International System of Units (SI: http://www.bipm.org/en/si/) should be used for units and abbreviations where appropriate. Examples of commonly used abbreviations include: year (y), week (wk), hour (h), minute (min), second (s), gram (g), liter (L), microliter (µL), meter (m), and degree Celsius (°C). For Turkish abbreviations, authors should refer to the website of the Turkish Language Association (TDK; http://www.tdk.gov.tr).

e) A period (.) should be used as the decimal separator, and a space should be left between the numerical value and the unit (e.g., 12.3 mm, 37 °C). No space should be left between the numerical value and the percent symbol when expressing percentages (e.g., 0.2%).

f) Unless the abbreviation represents a standard unit of measurement, it should be clearly defined in parentheses at its first occurrence in the text, and the same abbreviation should be used consistently throughout the manuscript.

g) The source of all materials/equipment used in the study should be specified at first mention, including the product name, manufacturer, city, state (if applicable), and country in parentheses. It is not necessary to provide the origin information in subsequent mentions of the same product. When referring to another product manufactured by a previously mentioned company, stating only the company name is sufficient.

TITLE PAGE

The title page should include the following:

a) The title of the manuscript (in English and Turkish).

b) A short running title not exceeding 5 words (in English and Turkish).

c) Full names of all authors, including academic degrees. The institutional affiliations of the authors (including city and country) should be indicated below the author line using superscript numbers following the surnames.

d) ORCID identifiers of all authors. Authors should obtain or verify their ORCID identifiers via https://orcid.org/

e) Contact information of the corresponding author, including postal address, office telephone number, mobile phone number, and e-mail address.

f) The type of manuscript (e.g., original research article, letter to the editor, case report, etc.).

g) The word counts of the abstract and main text separately (excluding figure legends, table titles, and references), together with the numbers of references, figures, and tables.

h) Funding information (please specify grant number, protocol number, etc., if applicable).

i) Acknowledgements (including whether the manuscript has previously been presented at any scientific meeting or congress).

j) Ethics committee approval information (full name of the committee, approval date, and approval number) should be stated both here and within the manuscript text. A digital copy of the approval document must be uploaded to the system as a separate file during submission.

k) Clinical trial registration information, including the registry name (e.g., clinicaltrials.gov), registration number, registration date, and internet link (recommended).

ABSTRACT AND KEYWORDS

The abstract should accurately reflect the content of the manuscript and should not include information that is not presented in the main text. The abstract must be structured using the following headings: Aim, Materials and Methods, Results, and Conclusion for original research articles; and Introduction, Case Report, and Conclusion for case reports. No subheadings should be used in technical notes or letters to the editor.

Abstracts and keywords should be provided in both English and Turkish. Keywords should be selected from the Medical Subject Headings (MESH:www.nlm.nih.gov/mesh/MBrowser.html) and Türkiye Bilim Terimleri (TBT; http://www.bilimterimleri.com) databases. Keywords should be listed alphabetically and separated by semicolons (;). Keywords should not be selected from the title or abstract, as these are indexed automatically; instead, they should be selected from the main text.

INTRODUCTION

The main concept and significance of the study should be clearly explained. This section should not include any results, discussion, or data. In the final paragraph of the section, the aim of the study should be clearly stated, and the research hypothesis, if any, should be provided.

MATERIALS AND METHODS

The sources of all commercial products and devices used in the study should be specified, including their trade names and manufacturers (name, manufacturer, city, and country).

This section should include information regarding ethical approval (full name of the Ethics Committee granting approval, approval date, and approval number). If applicable, it should also be stated that informed consent was obtained.

In observational or experimental studies, the inclusion and exclusion criteria for participant selection (including patients, control groups, and laboratory animals) should be clearly described.

In the final paragraph of this section, the statistical analysis should be described in detail. Statistical terms and symbols should be defined, and the computer software used for statistical analysis should be specified.

RESULTS

Statistical findings should be reported without discussion or interpretation. Tables, graphs, or illustrations should be used when necessary. Subheadings may be used in this section if required.

DISCUSSION

The findings of the study should be discussed and compared with those of previous studies, indicating areas of agreement or disagreement. The limitations of the study should also be addressed. Repetition of information already presented in the Introduction and Conclusion sections should be avoided.

CONCLUSION

In this section, the authors should briefly and clearly summarize the conclusions of the study and emphasize its main messages. Statistical details should not be included.

ACKNOWLEDGEMENTS

If the study was supported by a grant or any other funding source, the name of the supporting organization and/or the grant number should be stated in this section.

CONFLICT OF INTEREST

The authors should declare that there is no conflict of interest.

REFERENCES

Citation and referencing in ADO Journal of Clinical Sciences should follow the Vancouver style. References should be cited consecutively in the text using superscript Arabic numerals. The complete reference list should be provided in numerical order according to the order of citation in the text.

Journal titles should be abbreviated according to the style used in the MEDLINE List of Journals Indexed for MEDLINE. [NLM Catalog Journals Indexed for MEDLINE (http://www.ncbi.nlm.nih.gov/nlmcatalog/journals).

Unpublished data or personal communications should not be included in the reference list.

Examples of in-text citations:
"…as reported in a previous study."[1]
"…as reported in previous studies."[2,4-6,8]
"A recent study by Yılmaz[9] reported that:"
"A recent study by Yılmaz and Akın[10] reported that:"
"A recent study by Yılmaz et al.[11] reported that:"

Standard journal article

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.

Standard journal article with more than six authors

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.

Thesis

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

Book and book chapter

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.

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Editorial

Rethinking Peri-implantitis: Etiologic Heterogeneity, Tailored Treatment, and Long-Term Disease Control

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ABSTRACT

Peri-implantitis is a biofilm-mediated inflammatory disease with substantial etiologic heterogeneity and variable treatment outcomes. Its development appears to reflect the interaction of microbial dysbiosis and host susceptibility with local anatomical, implant-related, prosthetic, and maintenance-related factors, some of which may originate during implant therapy. This narrative review summarizes current evidence on factors associated with disease onset and progression and examines their implications for prevention, diagnosis, and treatment planning. Particular attention is given to stepwise therapy, including initial non-surgical disease control, correction of modifiable factors, implant-surface decontamination and preservation, indications for surgery, defect-oriented reconstructive and resective approaches, and the selective use of implantoplasty. Long-term outcomes are also considered in relation to residual disease activity, recurrence risk, and (SPIC). Current evidence supports an individualized, risk-based approach in which treatment intensity is adapted to disease severity, defect configuration, surface exposure, and patient-specific susceptibility. Treatment success can be maintained over time only when control of inflammation and progressive bone loss is sustained through structured.

Keywords: Biofilms; Complication; Keratinized mucosa; Peri-implantitis; Reconstructive therapy; Supportive therapy.

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INTRODUCTION

Peri-implantitis is a biofilm-mediated inflammatory disease associated with microbial dysbiosis that affects the tissues surrounding dental implants and is characterized by progressive peri-implant bone loss, which may compromise implant longevity and increase systemic inflammatory burden.[1,2] However, the direction, magnitude, and clinical relevance of the association between peri-implantitis and systemic inflammation remain to be fully established.[3] Recent systematic reviews have estimated its prevalence at approximately 20%–25% at the patient level, highlighting peri-implantitis as an increasingly important clinical and public health concern.[4,5] The magnitude of this burden is likely to increase further in parallel with the growing global use of implant-supported rehabilitation. The global dental implant market has been valued at approximately USD 5 billion and continues to expand, indicating that an increasing number of patients will enter long-term follow-up with potential susceptibility to biological complications.[6] Consequently, even a moderate prevalence of peri-implantitis may translate into a substantial treatment burden, particularly in countries where implant therapy is performed at high volumes.

Türkiye provides a relevant example of this expanding clinical burden. In addition to the widespread use of implant therapy, the country has an increasing role in dental implant production and international dental care. An industry estimate has suggested that approximately 5 million dental implants are placed annually in Türkiye.[7] Although this estimate is not derived from a nationwide implant registry, it illustrates the considerable scale of implant therapy and, consequently, the potentially large population exposed to peri-implant complications over time. This perspective gains further relevance when considered alongside available clinical data from Türki-

ye. In a cross-sectional study of 324 implants in 112 patients enrolled in a university-based supportive peri-implant care (SPIC) program, Isler *et al*. identified peri-implantitis at the patient level in 42% (based on the diagnosis of the most severely affected implant) and at the implant level in 30.5%.[8] The study also provided a comprehensive evaluation of the peri-implant soft-tissue phenotype while accounting for relevant confounding variables, including plaque levels, maintenance compliance, periodontal status, prosthesis type, implant location, and jaw. The absence of peri-implant keratinized mucosa (KM) and attached mucosa (AM), together with reduced vestibular depth, was significantly associated with a greater likelihood of peri-implantitis. Taken together, the high volume of implant therapy and the substantial prevalence observed in this well-characterized Turkish cohort illustrate the potential magnitude of peri-implantitis as an emerging oral healthcare challenge and emphasize the need for risk-based prevention, early recognition, and structured SPIC.

Against this background, the conventional view of peri-implantitis as a primarily biofilm-mediated inflammatory disease may not fully capture its etiologic heterogeneity. Although microbial dysbiosis and the host inflammatory response remain central to its pathogenesis, disease development appears to be influenced by the interaction of patient susceptibility with local anatomical, implant-related, surgical, prosthetic, and maintenance-related factors.[9] Importantly, some of these factors may arise during implant therapy and create local conditions that favor early tissue breakdown, implant surface exposure, impaired cleansability, and subsequent biofilm accumulation.[10] More recently, peri-implantitis has therefore also been discussed from a complication-based perspective, in which treatment-related factors may contribute to the conditions that permit disease initiation or progression. This view does not diminish the fundamental role of biofilm and inflammation; rather, it suggests that peri-implantitis may, in a proportion of cases, develop as a biofilm-mediated disease on the background of a treatment-related complication. Such an integrated framework shifts attention from clinical manifestations alone to identifying the combination of biological, anatomical, and treatment-related factors that enabled the disease to develop.

Accordingly, this narrative review reconsiders peri-implantitis within an etiologically heterogeneous disease–complication framework in which biofilm-mediated inflammation interacts with patient susceptibility and local anatomical, implant-related, surgical, prosthetic, and maintenance-related factors. The review synthesizes current evidence on factors associated with disease onset and progression and examines how their identification may inform prevention and risk control. It further discusses a stepwise treatment strategy from initial non-surgical disease control to defect-oriented surgical therapy, with particular attention to implant-surface decontamination and preservation, titanium-related considerations, reconstructive procedures, and the selective extent of surface modification. Finally, long-term treatment outcomes are considered in relation to residual disease activity, SPIC, and individualized risk management.

1- Peri-implantitis Within a Multifactorial Disease–Complication Framework

Peri-implantitis should not be regarded as an etiologically uniform disease. The development of peri-implantitis at some implants but not at others, even within the same patient, cannot be fully explained by biofilm accumulation alone, despite the fact that a dysbiotic biofilm is essential to its clinical manifestation. This site-specific pattern points to an interaction between patient susceptibility and local factors, including peri-implant anatomy, implant-related characteristics, surgical and prosthetic variables, operator-dependent influences, and maintenance conditions.[9,10]

At the biological level, the microbial challenge and the host inflammatory response form the core of the disease process. Patient-related characteristics encompass non-modifiable factors, such as a history of periodontitis,[1,11,12] as well as modifiable or potentially controllable factors, including inadequate plaque control,[13] smoking,[14,15] uncontrolled systemic factors such as hyperglycemia,[16] stress,[17] and irregular compliance with SPIC.[18] Collectively, these factors may influence immune regulation, tissue repair, and the capacity to control biofilm. However, these factors are unlikely to operate independently of the local peri-implant environment. Instead, these factors may increase local susceptibility to disease

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initiation or promote subsequent progression when they coexist with conditions that favor biofilm retention, impair peri-implant tissue stability, or result in exposure of the implant surface to the peri-implant sulcus.[10] Conversely, a local predisposing factor may remain clinically quiescent for extended periods when biofilm control, host inflammatory regulation, and professional supportive care are adequately maintained.

Exposure of the micro-rough implant surface to the peri-implant sulcus has been proposed as one mechanism linking treatment-related tissue alterations to subsequent biofilm-mediated inflammation. Although micro-rough surfaces have substantially improved osseointegration, their exposure may favor bacterial retention and complicate effective decontamination. Surface exposure alone, however, may not account for all cases of peri-implantitis; its clinical relevance is likely influenced by microbial challenge, host susceptibility, soft-tissue conditions, prosthetic cleansability, and maintenance compliance.[10]

2- Factors Associated with the Onset and Progression of Peri-implantitis

2.1. Patient Susceptibility: Established and Emerging Factors

Substantial evidence indicates that patients with history of periodontitis are at greater risk of developing peri-implantitis than periodontally healthy individuals.[1,11,12] This susceptibility is further increased in the presence of poor plaque control and residual periodontal pockets≥5 mm, particularly when accompanied by bleeding on probing (BOP), as these findings indicate incomplete periodontal stability and may sustain a pathogenic microbial burden. Accordingly, active periodontal therapy should be completed before implant placement, with the objectives of improving patient-performed plaque control, establishing compliance, and treating residual inflamed pockets. Thereafter, patients should be enrolled in an individualized supportive periodontal and peri-implant care program that includes regular assessment of both periodontal and peri-implant tissue conditions.[19]

Systemic conditions may influence the onset and progression of peri-implantitis by altering immune regulation, tissue repair, bone metabolism, and the peri-implant microbial environment. Among these factors, hyperglycemia is particularly relevant. Diabetes mellitus has been associated with an approximately 50% greater risk of peri-implantitis, especially when glycemic control is inadequate.[20] Elevated glucose levels may promote microbial dysbiosis, increase the accumulation of advanced glycation end products, amplify proinflammatory responses, and impair wound healing.[21] Conversely, peri-implant outcomes in patients with well-controlled diabetes may approach those observed in systemically healthy individuals. Implant therapy, particularly when extensive bone augmentation or complex surgical procedures are anticipated, should therefore be approached cautiously in patients with uncontrolled diabetes, poor compliance, or limited commitment to risk control and supportive care. Other uncontrolled systemic inflammatory or metabolic conditions may also modify peri-implant susceptibility, although the strength of evidence varies among conditions.

Among behavioral and metabolic factors, smoking has been consistently associated with an increased risk of peri-implantitis.[14,22] Its adverse effects may be mediated through impaired microcirculation, reduced tissue oxygenation, altered immune function, compromised wound healing, and promotion of a more pathogenic peri-implant microbiota.[23] Patients should therefore be informed of this increased risk and offered structured smoking-cessation support. Obesity and central adiposity have also emerged as potential systemic modifiers of peri-implant health. A body mass index ≥30 kg/m² has been associated with an approximately two-fold greater risk of peri-implant pocket deepening, while central adiposity has been linked to an approximately 1.9-fold higher risk of peri-implantitis even after adjustment for smoking.[24] These associations may reflect the chronic low-grade inflammatory state and metabolic dysregulation accompanying excess adiposity. Psychological stress may additionally influence peri-implant health through both biological and behavioral pathways. Evidence from cohorts with periodontal disease has shown that elevated salivary cortisol levels are associated with greater bleeding on probing and faster attachment loss, providing biological plausibility for a potential effect on peri-implant tissues. Direct evidence from peri-implantitis patients has also shown that higher stress levels are asso-

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ciated with increased salivary IL-1β, IL-6, and sAA expression together with reduced IL-10 expression, suggesting that psychological stress may amplify the inflammatory response.[17] Chronic activation of the hypothalamic–pituitary–adrenal axis and the sympathetic nervous system may further alter immune regulation and tissue repair,[25] while stress-related behavioral changes may adversely affect plaque control and maintenance compliance.[23] Nevertheless, direct evidence linking psychological stress to peri-implantitis remains limited, and stress should currently be considered a potential modifying factor rather than an established independent risk factor.

2.2. Site-, Implant-, and Prosthesis-Related Factors

The local peri-implant tissue environment may influence susceptibility to inflammation by affecting both tissue stability and the patient's ability to maintain effective plaque control. Particular attention has been directed toward the width and attachment of the peri-implant KM. Sites with <2 mm of KM have been associated with greater plaque accumulation, mucosal inflammation, recession, marginal bone loss, and discomfort during oral hygiene.[26-29] However, the protective role of peri-implant mucosa may depend not only on keratinization itself but also on its mechanical attachment to the underlying alveolar bone and the depth of the vestibule. Firmly AM may provide greater tissue stability around the prosthetic components, whereas mobile, non-attached mucosa, particularly in the presence of a shallow vestibule, may compromise plaque control and favor inflammatory changes.[9] A representative clinical example illustrating limited KM and AM, shallow vestibular depth, associated plaque accumulation, and peri-implant inflammatory changes is shown in Figure 1.

Supporting this broader concept of the peri-implant soft-tissue phenotype, Isler *et al*. evaluated width of KM, AM, mucosal thickness (MT), and vestibular depth simultaneously and demonstrated that the absence of KM, the absence of AM, and reduced vestibular depth were independently associated with peri-implantitis after adjustment for relevant confounders, including plaque, maintenance compliance, periodontal status, prosthesis type, implant location, and jaw.[8] Notably, the absence of keratinized mucosa was also associated with a distinct pro-inflammatory profile, including higher IFN-γ levels and, among irregular compliers, increased IL-1β and IL-21 levels, suggesting that an unfavorable soft tissue phenotype may influence not only mechanical stability and cleansability but also the local inflammatory environment.[8]

Recent long-term evidence provides further insight into this relationship. In a 25-year cohort of patients with generally adequate oral hygiene and regular SPIC, Couso-Queiruga *et al*. found that the absence of KM was associated with greater crestal bone loss, a higher prevalence of peri-implant soft-tissue dehiscence, and increased implant platform visibility.[30] However, neither the width of KM nor that of MT was significantly associated with the prevalence of peri-implant mucositis or peri-implantitis. Notably, the authors suggested that favorable oral hygiene and regular SPIC attenuated the influence of limited KM on peri-implant disease development. These findings suggest that the clinical impact of the peri-implant soft tissue phenotype is context dependent and may be modified by plaque control and maintenance behavior.

Accordingly, peri-implant soft tissue characteristics should be interpreted collectively and in conjunction with underlying bone support, plaque control, main-



Figure 1. Clinical presentation of peri-implantitis in a 61-year-old female patient after 9 years of implant function. Mandibular implant sites were characterized by limited keratinized mucosa (KM) and attached mucosa (AM), pronounced plaque accumulation, bleeding on probing, and suppuration.

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tenance compliance, and other site-specific risk factors, rather than relying exclusively on a single dimensional threshold.[8,30,31]

Implant-related characteristics may modify susceptibility to peri-implantitis by influencing peri-implant tissue stability, surface exposure, plaque retention, and the accessibility of the implant–prosthesis complex. Three-dimensional implant positioning is particularly relevant, as excessive facial placement, insufficient mesiodistal spacing, or inappropriate apico-coronal positioning may compromise the surrounding bone envelope and prosthetic emergence profile, thereby increasing the likelihood of early tissue breakdown and subsequent surface contamination.[10] Recent clinical data further support the relevance of implant position, showing lower odds of peri-implantitis for implants centered within the mesiodistal and buccolingual dimensions and adequately contained within the bony housing.[32] A representative clinical example illustrating unfavorable three-dimensional implant positioning, compromised peri-implant bone support, and subsequent peri-implant tissue breakdown is shown in Figure 2.

Implant macrodesign and connection characteristics may also contribute to this process. Tissue-level implants have shown a lower prevalence of peri-implantitis than bone-level implants in some observational studies, although these findings may partly reflect differences in restorative margin location, transmucosal design, surface characteristics, and other system-specific factors.[33] Long-term observations of tissue-level implants with a hybrid surface design have likewise reported low rates of peri-implantitis, supporting the potential relevance of limiting exposure of the micro-rough surface to the peri-implant environment.[34]

With respect to the implant–abutment interface, complete prevention of bacterial penetration appears difficult regardless of connection type; however, bacterial load has been reported to be lower with conical connections than with external or internal clearance-fit connections. Internal conical connections have also been associated with less marginal bone loss than external connections.[33] These observations are supported by a recent systematic review and meta-analysis, in which internal connections, particularly conical configurations, and



Figure 2. Clinical presentation of a 59-year-old female patient with implants in function for 12 years. The implants in the right maxillary quadrant were positioned toward the buccal aspect and were associated with reduced buccal bone support and insufficient peri-implant mucosa. The prosthetic restorations also exhibited inadequate marginal adaptation and overcontoured profiles.

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platform-switched abutments were associated with reduced marginal bone loss.[35] Nevertheless, direct evidence that connection geometry independently determines peri-implantitis remains limited, and available findings should primarily be interpreted in terms of preservation of crestal bone, mechanical stability, and reduction of microleakage. There is likewise no convincing evidence or biological rationale to suggest that a particular implant thread design independently predisposes to peri-implantitis.[9]

The evolution of implant surface design reflects the balance between promoting osseointegration and limiting the biological consequences of surface exposure. While micro-rough surfaces enhance bone anchorage and accelerate osseointegration, their exposure to the peri-implant environment may increase bacterial retention and complicate decontamination. Historical concerns regarding progressive bone loss around implants with roughened transmucosal surfaces contributed to the development of tissue-level and hybrid designs, in which a smoother coronal segment is intended to reduce the extent of rough surface exposed after marginal bone loss.[10] Experimental evidence further suggests that certain roughened surfaces may be associated with more rapid peri-implant breakdown once inflammation is established, whereas hybrid configurations may mitigate this effect by limiting exposed rough surface area.[9,10]

Overall, implant position, macrodesign, connection geometry, and surface characteristics may shape peri-implant disease susceptibility by affecting tissue stability, surface exposure, plaque retention, and long-term cleansability, rather than acting as isolated etiologic determinants.

Prosthetic design may influence peri-implant health by determining both the spatial relationship between the restoration and peri-implant tissues and the accessibility of the implant–prosthesis complex for biofilm control. Excessively convex or overcontoured emergence profiles may restrict access for patient-performed oral hygiene and professional instrumentation, thereby promoting plaque retention and persistence of inflammation.[36,37] Accordingly, cleansability should be regarded as a fundamental biological requirement of implant-supported restorations rather than solely as a prosthetic design consideration. Calciolari *et al*. emphasized that both the patient's and the clinician's ability to access and effectively decontaminate the implant is likely to influence treatment outcomes, and that implant-supported prostheses should be modified or replaced when their design compromises cleansability.[23]

Emergence angle and profile have received particular attention as potentially modifiable prosthetic factors. The systematic review and meta-analysis by Lin *et al*. found that, in bone-level implants, emergence angles >30° were associated with a higher prevalence of peri-implantitis than angles <30° (RR = 3.17), while convex profiles were associated with greater risk than concave or straight profiles (RR = 2.30).[35] However, these analyses were based on only two studies for each comparison, underscoring the need for longitudinal confirmation. Consistently, Janda and Mattheos identified overcontouring, emergence angle, and convexity as prosthetic features potentially associated with inflammation, marginal bone loss, recession, and peri-implantitis.[38] Importantly, these characteristics are modifiable: clinical evidence indicates that correction of overcontoured restorations to improve oral hygiene access can reduce bleeding and probing depths compared with leaving the prosthesis unchanged. Thus, the clinical relevance of prosthetic contour lies not in a single angular threshold, but in whether the restoration provides sufficient space for peri-implant tissues while remaining accessible for effective biofilm control.

Residual cement represents a distinct prosthesis-related factor because it may simultaneously act as a foreign material and a plaque-retentive substrate within the peri-implant sulcus. Observational evidence supports an association between excess cement and peri-implant inflammation, and the likelihood of residual cement may increase as the restorative margin is positioned deeper submucosally.[39] Laleman and Lambert reported that complete removal becomes particularly difficult when margins are located ≥2 mm subgingivally and considered cement remnants a potential precipitating factor for peri-implantitis.[33] Chen *et al*. similarly highlighted that retained cement may remain undetected, particularly on buccal and lingual surfaces, and that its biological impact may be amplified when deposited on an exposed micro-rough implant surface.[10] Nevertheless, the mode of

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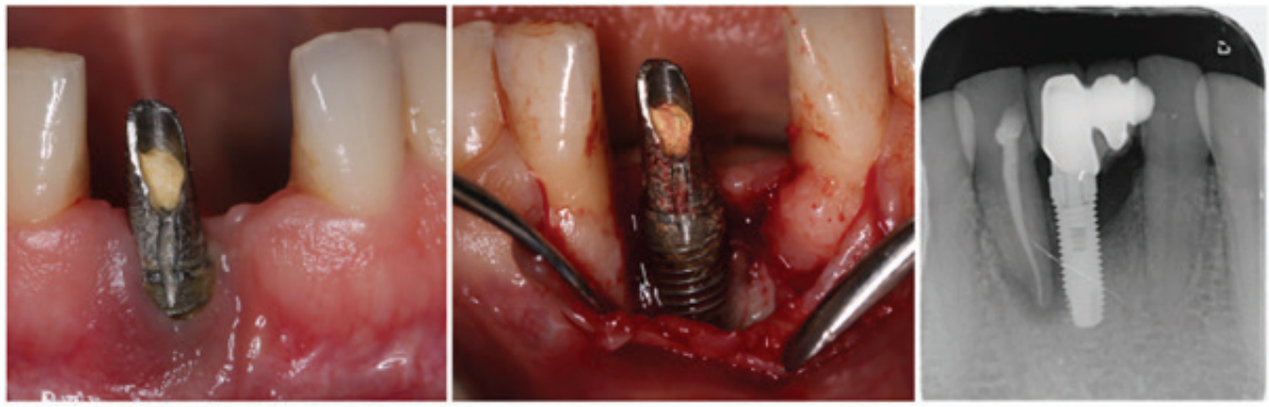


Figure 3. Clinical presentation of a 51-year-old female patient with implants in function for 11 years. In the mandibular anterior region, unfavorable implant positioning resulted in restoration of a relatively wide edentulous span with a cantilevered prosthetic design. Following flap elevation, residual cement was identified around the implant.

retention itself should not be regarded as inherently pathogenic. The meta-analysis by Lin *et al*. found no significant difference in marginal bone loss between screw- and cement-retained restorations, suggesting that the principal concern is residual cement and its accessibility for removal rather than cement retention per se.[35] Figure 3 presents a representative clinical example of a cantilevered prosthetic design in the presence of unfavorable implant positioning and retained submucosal cement.

Prosthetic misfit may compromise peri-implant stability through both biological and mechanical pathways. Gaps resulting from inaccurate restoration–abutment seating or component mismatch may facilitate bacterial accumulation and microleakage, whereas inadequate passivity or unstable connections may promote micromovement, screw loosening, component wear, and mechanical failure.[40,41] Chen *et al*. identified improper abutment seating, fabrication inaccuracies, incorrect tightening torque, repeated connection and disconnection, and non-passive fit of multi-unit restorations as potential contributors to prosthetic misfit and subsequent biological complications.[10] Component compatibility may further influence this interface: Janda and Mattheos noted that non-original components can differ from original components in geometry, tolerances, and microscopic dimensions, potentially affecting precision of fit and prosthetic performance.[38] Therefore, prosthetic fit should be considered not merely a technical endpoint but an integral component of biological risk control around implants.

3- Treatment Strategy: From Initial Disease Control to Surgical Escalation

3.1. Initial Non-Surgical Therapy: Biofilm Control, Modifiable Factors, and Surface Preservation

Initial management of peri-implantitis should focus on controlling the microbial challenge while identifying and, whenever possible, correcting modifiable factors that may contribute to persistent inflammation or compromise treatment outcomes.[42] Preventive and therapeutic measures should be integrated throughout implant therapy, beginning with patient education and individualized risk-factor control and continuing through SPIC.[18,28] Clinical and radiographic assessment should include longitudinal evaluation of peri-implant tissue conditions to identify changes requiring preventive or therapeutic intervention.[43] Professional decontamination should aim to remove supramarginal and submarginal deposits from the implant and prosthetic components while preserving their structural integrity. Accordingly, the selection of instrumentation should take into account implant characteristics, the nature and extent of biofilm and mineralized deposits, prosthesis design, peri-implant soft-tissue characteristics, and patient-specific factors.[44-46] These principles are consistent with contemporary SPIC concepts, in which professional decontamination, risk-factor assessment, patient education, and individualized oral-hygiene reinforcement are considered complementary components of long-term peri-implant care.

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A wide range of instrumentation protocols, differing in treatment frequency and in the combination of mechanical or physical approaches, has been investigated, with considerable heterogeneity in reported outcomes.[23] Consequently, current evidence is insufficient to establish the consistent superiority of any single instrumentation strategy, and instrument selection should consider both decontamination efficacy and the potential for titanium surface alteration. Conventional metallic curettes and metal ultrasonic or sonic tips may induce surface damage, particularly with increasing pressure or power, whereas titanium and carbon-fiber curettes may provide effective removal of mild-to-moderate deposits with less surface alteration.[47,48] Plastic-coated instruments are less abrasive but may be less effective against firmly adherent calculus.[49] Air-polishing devices represent another option for biofilm removal,[50] although their effects depend partly on the powder used, with larger and more abrasive particles such as sodium bicarbonate producing greater surface alterations than finer powders such as glycine or erythritol.[51] Comparative studies have not demonstrated consistent clinical superiority of ultrasonic instrumentation, hand instrumentation, or glycine air-polishing, and different SPIC protocols have yielded broadly comparable inflammatory outcomes when adequate plaque control and repeated oral-hygiene reinforcement were maintained.[19] Instrumentation should therefore be adapted to the clinical situation and the characteristics of the exposed implant surface.[52] Less abrasive approaches may be appropriate around implants without exposed threads or in peri-implant mucositis, whereas exposed threads or firmly adherent deposits may require instruments that provide greater mechanical access.[53] Ultrasonic or sonic instruments equipped with implant-compatible tips made from materials softer than titanium have also been developed to reduce instrumentation-related surface damage.[19] PEEK ultrasonic tips may limit surface damage compared with more abrasive metallic instruments; however, PEEK-derived remnants, including dark deposits, have been detected on titanium surfaces after instrumentation, indicating that reduced abrasiveness does not necessarily imply complete preservation of surface integrity.[54,55] Representative clinical examples illustrating different non-surgical physical and mechanical decontamination approaches are shown in Figure 4.

Prosthetic accessibility represents another important component of initial therapy. Implant-supported restorations may restrict both professional instrumentation and patient-performed plaque control. In selected situations, removal of the prosthesis may improve access for professional debridement, while modification of an overcontoured or otherwise poorly cleansable restoration may facilitate long-term biofilm control.[56,57] These local measures should be accompanied by individualized risk assessment. Structured approaches such as the Implant Disease Risk Assessment (IDRA) integrate patient-related, implant- and prosthesis-related, and clinical variables and may assist in tailoring preventive strategies and maintenance intervals.[58] Oral-hygiene instructions should likewise be individualized according to patient needs and prosthetic configuration, with appropriate selection of toothbrushes, interdental devices, floss, oral irrigators, dentifrices, and mouth rinses.[28]

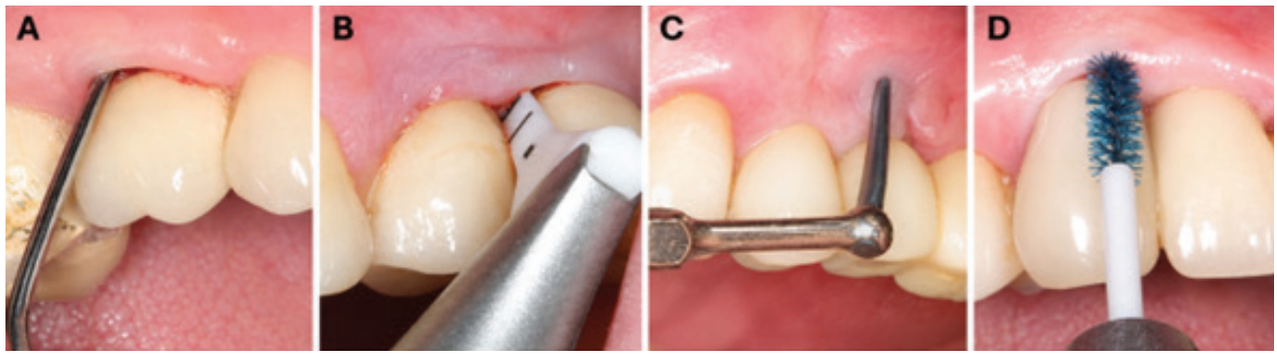


Figure 4. Representative clinical examples of submucosal mechanical decontamination approaches used during non-surgical peri-implantitis therapy: (A) titanium curette, (B) air-polishing device, (C) ultrasonic instrumentation with a PEEK tip, and (D) a chitosan brush (Labrida; Straumann).

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Beyond differences in decontamination efficacy, increasing attention has been directed toward the biological consequences of implant surface instrumentation. In particular, it has been questioned whether abrasive decontamination procedures may impair peri-implant tissue healing through mechanical alteration of the titanium surface and the release of titanium particles.[59,60] Recent experimental findings provide biological support for this concern. Jazaeri *et al*. reported that titanium curettes and rotating titanium brushes produced detectable alterations of microrough titanium surfaces and were associated with lower fibroblast viability after instrumentation, whereas non-contact pressurized waterjet irrigation resulted in greater biofilm reduction while largely preserving surface morphology and cytocompatibility.[61] Their surface analyses further demonstrated abrasion and delamination following curette and titanium-brush instrumentation, with evidence suggesting disruption or thinning of the protective oxide layer. These observations support the concept that surface preservation may represent an additional therapeutic objective alongside microbial decontamination. Nevertheless, the findings should be interpreted cautiously because the experiments were conducted on flat titanium disks with an immature biofilm under conditions that do not fully reproduce the anatomical and microbiological complexity of clinical peri-implantitis.

The biological relevance of titanium release, however, remains uncertain. Although bacterial plaque and dysbiotic biofilm remain the primary etiologic drivers of peri-implantitis, titanium ions and particles may also be released through tribocorrosion and other degradation processes and have been proposed as potential modifiers of the peri-implant inflammatory environment.[59] Experimental and translational evidence suggests that titanium degradation products may influence macrophage and neutrophil activation, proinflammatory mediator release, cellular viability, bone metabolism, and potentially microbial composition.[62,63] Higher concentrations of titanium particles have also been detected in diseased peri-implant tissues than at healthy sites.[62] However, these observations do not establish a causal role. Human histological investigations have not consistently identified a foreign-body reaction attributable to titanium particles, and molecular analyses have not demonstrated a clear relationship between titanium particle deposition and peri-implantitis-associated gene-expression patterns.[64] Accordingly, Monje *et al*. considered the available evidence regarding titanium particle toxicity inconclusive. Titanium degradation products may potentially modify local susceptibility or amplify an established plaque-associated inflammatory response, but current evidence does not support their interpretation as an independent etiologic cause of peri-implantitis.[9]

This uncertainty is also reflected in current clinical recommendations. The EFP treatment guideline recommends non-surgical instrumentation with curettes and/or sonic or ultrasonic devices, whereas the available evidence does not support the routine use of lasers or air-polishing for non-surgical treatment of peri-implantitis.[42] Thus, initial therapy should not be viewed solely as an attempt to maximize mechanical removal of biofilm. Rather, its objectives should include effective microbial control, correction of modifiable local and patient-related factors, improvement of prosthetic cleansability, and avoidance of unnecessary damage to the implant surface. Clinical response should be reassessed to determine whether these measures have achieved a maintainable peri-implant condition or require further therapeutic intervention.

3.2. Re-evaluation and Indications for Surgical Therapy

The response to initial non-surgical therapy should be systematically re-evaluated before selecting further intervention. The EFP S3 clinical practice guideline recommends a stepwise treatment pathway in which peri-implantitis therapy begins with a non-surgical phase and, according to the treatment response, proceeds either to SPIC or to surgical therapy.[42] The rationale for this approach is not only to determine whether biofilm and inflammation can be adequately controlled with less invasive measures, but also to improve patient-performed plaque control, address modifiable risk factors, and establish more favorable conditions before surgical intervention when required. Re-evaluation should therefore include the level of plaque control and patient compliance, residual probing pocket depth (PPD), BOP and suppuration on probing (SOP), prosthetic cleansability, and radiographic stability.

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Treatment response is best judged using a composite clinical and radiographic endpoint rather than PPD alone. According to the EFP guideline, disease resolution is characterized by PPD ≤5 mm, bleeding on probing at no more than one site, absence of SOP, and absence of progressive bone loss.[42] The importance of a composite assessment is also supported by contemporary clinical literature. Considerable heterogeneity exists in the definitions of treatment success used across peri-implantitis studies, although most rely on composite criteria that combine residual PPD thresholds with the limited or absence of BOP and SOP, and radiographic bone stability. Standardized assessment against these endpoints may therefore provide a more clinically meaningful basis for determining whether a maintainable peri-implant condition has been achieved.[42,65]

When these endpoints remain unmet after initial therapy, surgical intervention should be considered rather than relying on repeated cycles of non-surgical debridement. The EFP guideline specifically recommends surgical therapy when the non-surgical endpoints of PPD ≤5 mm and no more than one bleeding site have not been achieved.[42] This recommendation is supported by the observation that residual disease activity may compromise subsequent stability. Wang *et al*. reported that implants remaining with residual PPD ≥6 mm and persistent bleeding after non-surgical therapy were particularly susceptible to renewed breakdown, with more than half requiring retreatment within a few years.[10] Thus, persistent deep pockets, in conjunction with ongoing inflammation, appear to be clinically more relevant than pocket depth considered in isolation.

Recent clinical trials illustrate how these principles may be translated into surgical case selection. In the randomized trial by Park *et al*. implants selected for surgical therapy presented with radiographic bone loss ≥3 mm, PPD ≥6 mm, persistent bleeding and/or suppuration at re-evaluation 6–12 weeks after initial non-surgical therapy, and a pronounced supracrestal bone defect.[66] These criteria are broadly consistent with current guideline-based principles emphasizing persistent inflammation and residual deep pockets after initial therapy, although the exact numerical thresholds and defect-related requirements may vary across studies and clinical scenarios. Accordingly, the decision to proceed with surgery should integrate residual inflammatory activity, pocket depth, the extent and configuration of bone loss, and the accessibility of the affected implant surface rather than rely on a single parameter alone. Notably, the same trial compared rotating titanium brushes with implantoplasty and found titanium-brush instrumentation to be non-inferior in terms of PPD reduction and composite treatment success, with pocket closure achieved in 80% of implants in both groups at 12 months and better preservation of marginal bone levels in the titanium-brush group. More recently, Monje *et al*. reported that, in combined defects, extending implantoplasty from the supracrestal portion into the contained intrabony component was associated with greater improvement in bleeding scores and marginal bone-level gain than supracrestal implantoplasty alone, although this was accompanied by greater mucosal recession and no significant adjusted difference in overall disease resolution.[67]

Together, these findings suggest that surgical treatment should be tailored not only to the presence of residual disease but also to the defect configuration and the extent to which the exposed implant surface needs to be modified or decontaminated.

3.3. Surgical Therapy Based on Defect Configuration and the Extent of Surface Modification

Following the indication for surgical therapy, selection of the surgical approach should take into account the anatomical characteristics of the peri-implant defect, together with the location and extent of the implant surface requiring decontamination or modification. Defect morphology may influence surgical access, graft containment, clot stability, and the feasibility of reconstructive therapy. Accordingly, contained defects with a substantial intrabony component are generally considered more suitable for reconstructive approaches, whereas predominantly supracrestal or fully non-contained defects are more often managed with access or resective procedures. Combined surgical approaches may be particularly relevant in partially contained defects in which reconstructive and non-reconstructive components coexist.[68,69]

Clinical evidence also suggests that individual morphological features may influence specific aspects of the therapeutic response, although their prognos-

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tic value is not uniform across outcomes. A greater number of residual osseous walls has been associated with greater marginal bone-level gain, while the presence of a buccal bony wall has been linked to changes in probing depth following reconstructive therapy.[70,71] Long-term observations further suggest that defect configuration may be related to clinically relevant events such as recurrence, retreatment, and implant loss (Figure 5).[72] More recent evidence also supports caution in assigning prognostic significance to defect type. In the randomized trial by Paterno Holtzman *et al*. defect morphology was not significantly associated with the likelihood of disease resolution at 12 months, irrespective of whether resolution.[73] However, these associations have not been reproduced consistently across studies, and morphology has often been evaluated only descriptively or through selected structural characteristics rather than as a predefined independent prognostic variable. Accordingly, defect configuration appears better suited to informing surgical planning than to predicting treatment outcome in isolation.[74]

Reconstructive therapy is particularly relevant when sufficient residual bony walls remain to provide defect containment. However, current randomized evidence indicates that the addition of reconstructive measures does not necessarily translate into superior control of peri-implant inflammation.[68,75,76] In contained 3- and 4-wall defects, Heitz-Mayfield *et al*. found similar 12-month clinical and radiographic improvements following access-flap surgery and guided bone reconstruction with a xenograft and collagen membrane; successful outcomes were achieved in 90% and 85% of implants, respectively, without significant intergroup differences.[68] More recently, Hakkers *et al*. reported that reconstruction with autogenous bone, xenograft, and a collagen

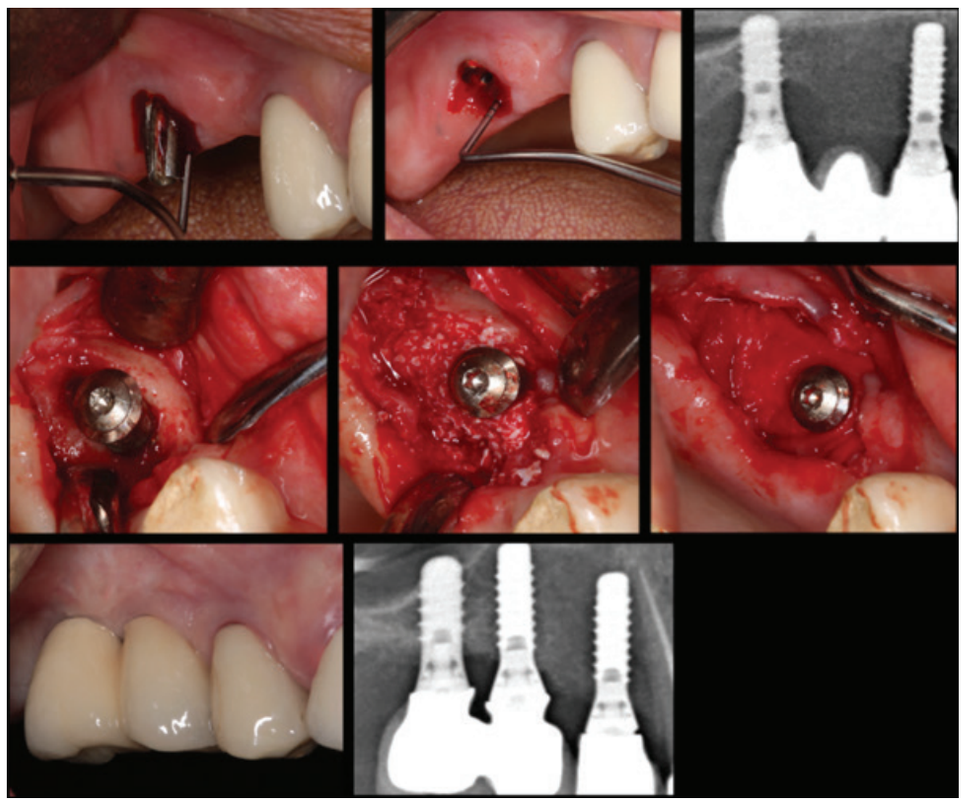


Figure 5. Clinical and radiographic presentation of a 44-year-old female patient with a contained peri-implant bone defect at implant site 16. The defect was reconstructed using particulate deproteinized bovine bone mineral (DBBM) and a collagen membrane. Clinical and radiographic findings at the 7-year follow-up are also shown (72).

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membrane in 3- and 4-wall defects resulted in more favorable marginal bone levels and less mid-buccal recession than open-flap debridement, whereas PPD, BOP, SOP, and disease resolution did not differ significantly between approaches.[76] These findings suggest that reconstructive therapy may provide structural and soft-tissue benefits in appropriately contained defects, but such radiographic gains should not be interpreted as synonymous with superior disease resolution or confirmed re-osseointegration. Hakkers *et al*. also cautioned that radiographic defect fill, particularly in the presence of radiopaque graft materials, does not by itself establish true biological regeneration.[76]

Another issue in reconstructive peri-implantitis therapy concerns the additional use of barrier membranes. Their routine application should not be assumed whenever grafting is performed, but rather considered according to the characteristics of the defect and the intended reconstructive strategy. Dionigi *et al*. in the 3-year follow-up of a randomized clinical trial, found no significant clinical, radiographic, or patient-reported benefit from adding a resorbable collagen membrane to a xenogeneic bone substitute.[77] Disease resolution was comparable between membrane and non-membrane groups, despite overall improvements in PPD, BOP, and marginal bone levels.[77] Together with other randomized trials, these findings indicate that membrane placement should not be considered an obligatory component of peri-implant defect reconstruction. A related consideration is whether soft-tissue augmentation may provide additional benefit when combined with reconstructive therapy. In a recent dual-center randomized clinical trial, Paterno Holtzman *et al*. reported that the addition of a connective tissue graft to guided bone regeneration resulted in greater clinical attachment and KM gains at 12 months, while disease resolution remained comparable with guided bone regeneration alone.[73] These findings suggest that adjunctive soft-tissue grafting may improve selected peri-implant tissue outcomes, although its contribution to disease resolution and long-term stability. requires further investigation.

Defect configuration also has implications for the extent of implant surface modification. In combined defects, a conventional strategy has been to perform implantoplasty on the supracrestal implant portion or on surfaces located outside the bony housing, while attempting to preserve and decontaminate the surface within the contained intrabony component before reconstruction. Monje *et al*. directly tested whether implantoplasty should be extended into this intrabony compartment by comparing partial-length implantoplasty with full-length implantoplasty in combined defects.[67] Extending implantoplasty into the contained intrabony portion was associated with greater improvement in bleeding scores and greater marginal bone-level gain, whereas PPD reduction was similar between groups. However, full-length implantoplasty was also associated with greater mucosal recession, and the apparent difference in disease resolution did not remain statistically significant after adjustment. These findings support a selective approach in which the extent of implantoplasty is determined by the relationship of the exposed rough surface to the bony housing, defect containment, reconstructive potential, and the anticipated soft-tissue consequences, rather than routinely modifying the entire exposed implant surface.

4- Long-Term Outcomes, SPIC, and Risk Management

Long-term stability after peri-implantitis treatment should be regarded as sustained disease control rather than merely the preservation of the implant or a short-term reduction in inflammatory parameters. Available long-term evidence indicates that favorable outcomes can be maintained in a substantial proportion of treated implants, although complete and durable disease resolution remains difficult to achieve. In their review of long-term surgical studies, Monje *et al*. reported a mean disease resolution rate of 58.6%, while arrest of progressive bone loss was observed in 69.6% of implants and resolution of bleeding on probing in 59.9%.[69] Implant survival averaged 88.6%, but retreatment was required in approximately 27% of cases.[69] These figures should be interpreted cautiously because of substantial heterogeneity in surgical approaches, definitions of treatment success, and follow-up protocols; nevertheless, they indicate that implant survival alone may overestimate the biological success of peri-implantitis therapy.

The condition achieved at the end of active therapy appears particularly relevant to subsequent sta-

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bility. Among the prognostic indicators evaluated in long-term studies, residual probing pockets following surgical treatment showed the strongest association with disease recurrence. Monje *et al*. reported that residual PPD ≥6 mm during follow-up were strongly associated with disease recurrence (OR = 7.3–9.2), while a greater extent of bone loss was also associated with recurrence (OR = 1.3).[69] Reduced KM width after healing has been associated with less favorable long-term treatment outcomes, while modified implant surfaces have been associated with an increased risk of recurrence or implant loss following surgical peri-implantitis therapy.[8,78] These observations reinforce the importance of achieving a peri-implant environment that is not only clinically improved but also maintainable. Persistent deep pockets, particularly when accompanied by BOP or SOP, should therefore be regarded as indicators of increased susceptibility to renewed breakdown rather than as stable residual anatomy. Wang *et al*. similarly emphasized that residual PPD ≥6 mm combined with inflammatory signs is associated with a higher probability of recurrence or progression during supportive care.[10]

SPIC is therefore an integral component of long-term peri-implantitis management rather than an optional post-treatment measure. Regular supportive care has been associated with lower rates of peri-implantitis, implant loss, and additional surgical intervention, whereas irregular attendance is repeatedly associated with less favorable outcomes.[10] Current evidence does not support a single recall interval for all patients. Relatively short intervals are generally appropriate following peri-implantitis treatment, particularly during the first year, while subsequent scheduling should be individualized according to patient-, implant-, site-, and prosthesis-related risk characteristics. Wang *et al*. summarized current guideline-based recommendations as approximately 3-month recalls initially, followed by 3- to 4-month intervals during the first year, with subsequent intervals of 3, 6, or 12 months selected according to individual risk.[10] Patients with a history of periodontitis, residual deep pockets, compromised bone support, poor plaque control, or other persistent risk indicators may require closer monitoring.

Importantly, SPIC should extend beyond repeated professional debridement. Long-term management should include reassessment of plaque control, probing depths, bleeding and suppuration, periodontal stability, prosthetic cleansability, and modifiable patient- and site-related factors, with radiographic evaluation performed when clinically indicated. Particular attention should be directed toward conditions that may favor renewed biofilm accumulation or impair effective maintenance, including residual periodontal pockets, inaccessible prosthetic contours, inadequate plaque control, and irregular compliance. It has been emphasized that structured SPIC, combining individualized risk assessment, professional biofilm control, tailored oral hygiene reinforcement, and modification of relevant risk factors, is associated with greater long-term tissue stability; however, the available evidence remains insufficient to establish the superiority of any specific maintenance protocol.[10]

Accordingly, long-term management after peri-implantitis therapy should be viewed as a dynamic process of surveillance and risk modification rather than a fixed recall schedule. Treatment intensity and recall frequency may need to be adjusted over time according to residual disease activity, maintenance compliance, periodontal and peri-implant tissue conditions, and the persistence or emergence of modifiable risk indicators.

CONCLUSION

Current evidence supports a view of peri-implantitis as an etiologically heterogeneous, biofilm-mediated inflammatory disease whose development and progression are influenced by the interaction of patient susceptibility with local anatomical, implant-related, prosthetic, and maintenance-related factors. Treatment should therefore be individualized and stepwise, beginning with biofilm control, correction of modifiable factors, and preservation of implant surface integrity, followed by surgical intervention when adequate disease control is not achieved. Surgical therapy should be adapted to defect configuration and the extent of surface exposure, with reconstructive procedures and implant surface modification applied selectively rather than routinely. Long-term success depends not only on implant retention, but on sustained control of inflammation and bone loss through structured, risk-based supportive peri-implant care.

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CONFLICTS OF INTEREST

The author declares no potential conflict of interests with respect to this study.

AI STATEMENT

The author used ChatGPT, an artificial intelligence–based natural language processing tool, solely for proofreading, language editing, and improving the clarity of the manuscript.

REFERENCES

1. Berglundh T, Armitage G, Araujo MG, *et al*. Peri-implant diseasesand conditions: consensus report of workgroup 4 of the 2017 world workshop on the classification of periodontal and peri-implant diseases and conditions. J Periodontol. 2018;89(suppl 1):S313-8.

2. Cafferata EA, Schwarz F. Peri-implantitis: a systemic burden for our patients. Front Dent Med. 2026;7:1774378.

3. Blanco C, Linares A, Dopico J, *et al*. Peri- implantitis, systemic inflammation, and dyslipidemia: a cross- sectional biochemical study. J Periodontal Implant Sci. 2021;51:342-51.

4. Reis I, Reis INR d, Huamán- Mendoza AA, *et al*. The prevalence of peri- implant mucositis and peri- implantitis based on the World workshop criteria: a systematic review and meta- analysis. J Dent. 2025;160:105914.

5. Diaz P, Gonzalo E, Villagra LJG, Miegimolle B, Suarez MJ. What is the prevalence of peri- implantitis? A systematic review and meta-analysis. BMC Oral Health. 2022;22:449.

6. Monje A, Pons R, Ramanauskaite A, Castro A, Schwarz F, Chambrone L. Long-term surgical treatment outcomes of peri-implantitis. Periodontol 2000. 2025 Jul 22. doi: 10.1111/prd.12643. Epub ahead of print.

7. Ege E. Türkiye diş implantı ihracatında yeni pazarlara odaklandı. Anadolu Ajansı. Published July 22, 2026. Accessed August 10, 2026. Available from: https://www.aa.com.tr/tr/isdunyasi/vakif-dernek/turkiye-dis-implanti-ihracatinda-yeni-pazarlara-odaklandi/703542

8. Isler SC, Romandini M, Akca G, Bakirarar B, Unsal B, Romanos G, Sculean A. Soft-Tissue Phenotype as a Risk Indicator of Peri-Implantitis and Peri-Implant Soft-Tissue Dehiscence-A Cross-Sectional Study. J Clin Periodontol. 2024;51:1443-57.

9. Monje A, Jung RE, Valles C, Naenni N. Emerging risk factors influencing the occurrence of peri-implantitis. Periodontol 2000. 2026 Mar 25. doi: 10.1111/prd.70031. Epub ahead of print.

10. Chen ST, Monje A, Strauss FJ, Schwarz F, Roccuzzo A, Sailer I, Tarnow D, Lambert F, Jovanovic S, Buser D. Peri-implantitis-Is it mainly a clinician-initiated complication of implant therapy? Periodontol 2000. 2026 Jun 8. doi: 10.1111/prd.70051. Epub ahead of print.

11. Carra MC, Range H, Swerts PJ, Tuand K, Vandamme K, Bouchard P. Effectiveness of implant- supported fixed partial denture in patients with history of periodontitis: a systematic review and meta-analysis. J Clin Periodontol. 2022;49(Suppl 24):208-23.

12. Roccuzzo A, Weigel L, Marruganti C, *et al*. Longitudinal assessment of peri- implant diseases in patients with and without history of periodontitis: a 20- year follow- up study. Int J Oral Implantol. 2023;16:211-222.

13. Fu JH, Wang HL. Breaking the wave of peri-implantitis. Periodontol 2000. 2020;84:145-60.

14. Reis INRD, do Amaral GCLS, Hassan MA, Villar CC, Romito GA, Spin-Neto R, Pannuti CM. The influence of smoking on the incidence of peri-implantitis: A systematic review and meta-analysis. Clin Oral Implants Res. 2023;34:543-54.

15. Elena C, Stefano C, Marina D, Pinar E, Nikolaos D. Tobacco Smoking and Smoke-Free Products as Risk Factors for Dental Implants: A Systematic Review. Clin Oral Implants Res. 2026;37:262-86.

16. Trullenque-Eriksson A, Bitencourt FV, Tomasi C, Berglundh T, Derks J. Association Between Diabetes and Peri-Implantitis: Evidence From a Swedish Register-Based Study. J Clin Periodontol. 2025 Dec;52:1650-61.

17. Soysal F, Unsal B, Isler SC, Akca G, Bakirarar B, Ozcan M. Evaluation of salivary stress markers and inflammatory cytokine levels in peri-implantitis patients. Clin Oral Investig. 2024;28:290.

18. Costa FO, Costa AM, Ferreira SD, *et al*. Long-term impact of patients' compliance to peri-implant maintenance therapy on the incidence of peri-implant diseases: An 11-year prospective follow-up clinical study. Clin Implant Dent Relat Res. 2023;25(2):303-312.

19. Wang HL, Calatrava J, Soldini MC, Vilarrasa J, Sculean A, Monje A. Long-term periodontal and peri-implant tissue stability under supportive therapy. Periodontol 2000. 2026 Apr 9. doi: 10.1111/prd.70038. Epub ahead of print.

20. Monje A, Catena A, Borgnakke WS. Association between diabetes mellitus/hyperglycaemia and peri- implant diseases: systematic review and meta- analysis. J Clin Periodontol. 2017;44:536-48.

21. Lv X, Zou L, Zhang X, Zhang X, Lai H, Shi J. Effects of diabetes/hyperglycemia on peri-implant biomarkers and clinical and radiographic outcomes in patients with dental implant restorations: A systematic review and meta-analysis. Clin Oral Implants Res. 2022;33:1183-98.

22. Dreyer H, Grischke J, Tiede C, *et al*. Epidemiology and risk factors of peri- implantitis: a systematic review. J Periodontal Res.2018;53:657-81.

23. Calciolari E, Rivara F, Donos N, Lasserre JF, Toma S. Factors affecting the efficacy of nonsurgical therapy of peri-implantitis. Periodontol 2000. 2026 Apr 16. doi: 10.1111/prd.70034. Epub ahead of print.

© 2026 İşler

24. Monje A, Wang HL, Nart J. Association of Preventive Maintenance Therapy Compliance and Peri- Implant Diseases: a cross- sectional study. J Periodontol. 2017;88:1030-41.

25. Emdin CA, Rothwell PM, Salimi-Khorshidi G, *et al*. Blood Pressure and Risk of Vascular Dementia: Evidence From a Primary Care Registry and a Cohort Study of Transient Ischemic Attack and Stroke. Stroke. 2016;47(6):1429-35.

26. Ramanauskaite A, Schwarz F, Sader R. Influence of width of keratinized tissue on the prevalence of peri- implant diseases: a systematic review and meta- analysis. Clin Oral Implants Res. 2022;33(Suppl 23):8-31.

27. Stefanini M, Barootchi S, Sangiorgi M, *et al*. Do soft tissue augmentation techniques provide stable and favorable peri- implant conditions in the medium and long term? A systematic review. Clin Oral Implants Res. 2023;34(Suppl 26):28-42.

28. Carra MC, Blanc- Sylvestre N, Courtet A, Bouchard P. Primordial and primary prevention of peri- implant diseases: a systematic review and meta- analysis. J Clin Periodontol. 2023;50(Suppl26):77-112.

29. Tavelli L, Barootchi S, Vera Rodriguez M, *et al*. Early soft tissue changes following implant placement with or without soft tissue augmentation using a xenogeneic cross- link collagen scaffold: a volumetric comparative study. J Esthet Restor Dent. 2022;34:181-7.

30. Couso-Queiruga E, Raabe C, Roccuzzo A, Salvi GE, Fonseca M, Chappuis V. Impact of Keratinized Mucosa Width and Mucosal Thickness on Implant Outcomes and Brushing Discomfort: A 25-Year Cohort Study. J Clin Periodontol. 2026 Aug 6. doi: 10.1111/jcpe.70187. Epub ahead of print.

31. Galarraga-Vinueza ME, Tavelli L. Soft tissue features of peri-implant diseases and related treatment. Clin Implant Dent Relat Res. 2023;25:661-81.

32. Monje A, Pons R, Soldini MC, Rosen PS, Nart J, Buser D. Role of Local Factors on the Occurrence of Peri-Implantitis: A Cross-Sectional Analysis. Clin Oral Implants Res. 2025;36:1614-25.

33. Laleman I, Lambert F. Implant connection and abutment selection as a predisposing and/or precipitating factor for peri-implant diseases: A review. Clin Implant Dent Relat Res. 2023;25:723-33.

34. Derks J, Schaller D, Hakansson J, Wennstrom JL, Tomasi C, Berglundh T. Effectiveness of implant therapy analyzed in a Swedish population: prevalence of peri- implantitis. J Dent Res. 2016;95:43-9.

35. Lin GH, Lee E, Barootchi S, Rosen PS, Curtis D, Kan J, Wang HL. The influence of prosthetic designs on peri-implant bone loss: An AO/AAP systematic review and meta-analysis. J Periodontol. 2025;96:634-51.

36. Katafuchi M, Weinstein BF, Leroux BG, Chen YW, Daubert DM. Restoration contour is a risk indicator for peri-implantitis: A cross-sectional radiographic analysis. J Clin Periodontol. 2018;45:225-32.

37. Pelekos G, Chin B, Wu X, Fok MR, Shi J, Tonetti MS. Association of crown emergence angle and profile with dental plaque and inflammation at dental implants. Clin Oral Implants Res. 2023;34:1047-57.

38. Janda M, Mattheos N. Prosthetic design and choice of components for maintenance of optimal peri-implant health: a comprehensive review. Br Dent J. 2024;236:765-71.

39. Staubli N, Walter C, Schmidt JC, Weiger R, Zitzmann NU. Excess cement and the risk of peri-implant disease – a systematic review. Clin. Oral Impl. Res. 28, 2017, 1278–90.

40. Abdelrehim A, Etajuri EA, Sulaiman E, Sofian H, Salleh NM. Magnitude of misfit threshold in implant-supported restorations: A systematic review. J Prosthet Dent. 2024;132:528-35.

41. Fernandes PF, Grenho L, Fernandes MH, Sampaio-Fernandes JC, Gomes PS. Microgap and bacterial microleakage during the osseointegration period: An *in vitro* assessment of the cover screw and healing abutment in a platform-switched implant system. J Prosthet Dent. 2023;130:87-95.

42. Herrera D, Berglundh T, Schwarz F, *et al*. Prevention and treatment of peri- implant diseases-the EFP S3 level clinical practice guideline. J Clin Periodontol. 2023;50(Suppl 26):4-76.

43. Renvert S, Persson GR, Pirih FQ, Camargo PM. Peri-implant health, peri-implant mucositis, and peri- implantitis: case definitions and diagnostic considerations. J Clin Periodontol. 2018;45(Suppl 20):S278-85.

44. Monje A, Amerio E, Cha JK, *et al*. Strategies for implant surface decontamination in peri-implantitis therapy. Int J Oral Implantol (Berl). 2022;15:213-48.

45. Sanz-Martin I, Paeng K, Park H, Cha JK, Jung UW, Sanz M. Significance of implant design on the efficacy of different peri- implantitis decontamination protocols. Clin Oral Investig. 2021;25:3589-97.

46. Yin W, Yang Y, Bao R, Chen X. Necessity of removing implant-supported prostheses when conducting supportive peri-implant therapy: a clinical study. J Prosthet Dent. 2025;134:2239-45.

47. Cha JK, Paeng K, Jung UW, Choi SH, Sanz M, Sanz-Martin I. The effect of five mechanical instrumentation protocols on implant surface topography and roughness: a scanning electron microscope and confocal laser scanning microscope analysis. Clin Oral Implants Res. 2019;30:578-87.

48. Kawashima H, Sato S, Kishida M, Ito K. A comparison of root surface instrumentation using two piezoelectric ultrasonic scalers and a hand scaler *in vivo*. J Periodontal Res. 2007;42:90-5.

49. Louropoulou A, Slot DE, Van der Weijden F. The effects of mechanical instruments on contaminated titanium dental implant surfaces: a systematic review. Clin Oral Implants Res. 2014;25:1149-60.

50. Ronay V, Merlini A, Attin T, Schmidlin PR, Sahrmann P. I*n vitro* cleaning potential of three implant debridement methods. Simulation of the non-surgical approach. Clin Oral Implants Res. 2017;28:151-5.

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51. Eraydin-Tufek N, Ozcan G, Isler SC. Efficacy of different nonsurgical treatments for peri-implantitis: a multi-arm randomized controlled clinical trial. Sci Rep. 2026;16:20370.

52. Perussolo J, Donos N. Maintenance of peri-implant health in general dental practice. Br Dent J. 2024;236(10):781-789.

53. Laleman I, Cortellini S, De Winter S, *et al*. Subgingival debridement: end point, methods and how often? Periodontol 2000. 2017;75:189-204.

54. Sahrmann P, Winkler S, Gubler A, Attin T. Assessment of implant surface and instrument insert changes due to instrumentation with different tips for ultrasonic-driven debridement. BMC Oral Health. 2021;21:25.

55. Ichioka Y, Derks J, Dahlén G, Berglundh T, Larsson L. Mechanical removal of biofilm on titanium discs: An *in vitro* study. J Biomed Mater Res B Appl Biomater. 2022;110:1044-55.

56. Pons R, Nart J, Valles C, Salvi GE, Monje A. Self-administered proximal implant-supported hygiene measures and the association to peri-implant conditions. J Periodontol. 2021;92:389-99.

57. de Tapia B, Mozas C, Valles C, Nart J, Sanz M, Herrera D. Adjunctive effect of modifying the implant-supported prosthesis in the treatment of peri-implant mucositis. J Clin Periodontol. 2019;46:1050-60.

58. Heitz-Mayfield LJA, Heitz F, Lang NP. Implant disease risk assessment IDRA – a tool for preventing peri-implant disease. Clin Oral Implants Res. 2020;31:397-403.

59. Safioti LM, Kotsakis GA, Pozhitkov AE, Chung WO, Daubert DM. Increased levels of dissolved titanium are associated with peri-implantitis-a cross-sectional study. J Periodontol. 2017;88:436-42.

60. Daubert D, Lee E, Botto A, Eftekhar M, Palaiologou A, Kotsakis GA. Assessment of titanium release following non-surgical peri-implantitis treatment: a randomized clinical trial. J Periodontol. 2023;94:1122-32.

61. Jazaeri MS, Siddiqui DA, Tsai YC, Gabel K, Lorenzana Z, Kotsakis GA. Biofilm removal capacity and titanium surface integrity in non-abrasive versus abrasive peri-implantitis cleaning interventions. J Periodontol. 2026;97:498-510.

62. Suarez-Lopez Del Amo F, Garaicoa-Pazmino C, Fretwurst T, Castilho RM, Squarize CH. Dental implants-¬ associated release of titanium particles: a systematic review. Clin Oral Implants Res. 2018;29:1085-100.

63. Souza JGS, Costa Oliveira BE, Bertolini M, *et al*. Titanium particles and ions favor dysbiosis in oral biofilms. J Periodontal Res. 2020;55:258-66.

64. Rakic M, Radunovic M, Petkovic-Curcin A, Tatic Z, Basta-Jovanovic G, Sanz M. Study on the immunopathological effect of titanium particles in peri-implantitis granulation tissue: a case-control study. Clin Oral Implants Res. 2022;33:656-66.

65. Ganesan SM, Fraser DR, Tattan M, Latimer JM; IADR IRG Peri-Implantitis Best Evidence Consensus Working Group 2; Kotsakis G. Biomaterials for resolution of peri-implantitis: Consensus report of Workgroup 2 of the IADR Implantology Research Group Best Evidence Consensus Symposium on Peri-Implant Disease and Its Treatment. J Periodontol. 2026 Mar 30. doi: 10.1002/JPER.24-0432. Epub ahead of print.

66. Park SH, Kim DB, Kim DM, Sanz-Martin I, Sanz-Sanchez I, Derks J, Cha JK. Implantoplasty vs. Rotating Titanium Brushes in the Surgical Treatment of Peri-Implantitis: A 1-Year Randomised Controlled Clinical Trial. J Clin Periodontol. 2026;53:244-55.

67. Monje A, Pons R, Aparicio C, Tarnow D, Rosen PS, Nart J. Extent of Implantoplasty in the Combined Surgical Therapy of Peri-Implantitis: A Quasi-Randomized Clinical Trial. Clin Implant Dent Relat Res. 2026;28:e70144.

68. Heitz-Mayfield LJA, Heitz F, Koong B, Huang T, Chivers P. Surgical peri-implantitis treatment with and without guided bone regeneration. A randomized controlled trial. Clin Oral Implants Res. 2023;34:892-910.

69. Monje A, Pons R, Ramanauskaite A, Castro A, Schwarz F, Chambrone L. Long-term surgical treatment outcomes of peri-implantitis. Periodontol 2000. 2025 Jul 22. doi: 10.1111/prd.12643. Epub ahead of print.

70. Isehed C, Holmlund A, Renvert S, Svenson B, Johansson I, Lundberg P. Effectiveness of enamel matrix derivative on the clinical and microbiological outcomes following surgical regenerative treatment of peri-implantitis. A randomized controlled trial. J Clin Periodontol. 2016;43:863-73.

71. Isler SC, Soysal F, Tunc S, Kaymaz O, Unsal B, Roccuzzo A. Impact of peri- implant keratinized mucosa width on the long-term reconstructive outcomes of peri-implantitis: a retrospective analysis with a follow-up up to 10 years. Clin Implant Dent Relat Res. 2024;26:819-31.

72. Isler SC, Soysal F, Ceyhanli T, Unsal B, Imber JC, Roccuzzo A. Long-term treatment outcomes of peri-implantitis reconstructive therapy: 7-year survival and success of a randomized clinical trial. Clin Oral Implants Res. 2025;36:1202-18.

73. Holtzman LP, Milinkovic I, Vuckovic M, Malpassi C, Cuppini M, Solderer A, Aleksic Z, Cordaro L. Effect of Connective Tissue Graft as an Adjunct to Guided Bone Regeneration in the Surgical Treatment of Peri-Implantitis: A Dual-Center Randomized Controlled Trial. Clin Oral Implants Res. 2026;37:478-95.

74. Suárez F, Monje A. Influence of defect morphology on the therapeutic outcomes of peri-implantitis. Periodontol 2000. 2026 Aug 25. doi: 10.1111/prd.70081. Epub ahead of print.

75. Derks J, Ortiz-Vigón A, Guerrero A, *et al*. Reconstructive surgical therapy of peri-implantitis: A multicenter randomized controlled clinical trial. Clin Oral Implants Res. 2022;33:921-44.

76. Hakkers J, de Waal YCM, Gareb B, Meijer HJA, Raghoebar GM. Surgical Reconstructive Peri-Implantitis Treatment for 3- and 4-Wall Bone Defects: A Single-Blind Randomised Controlled Trial With a 1-Year Follow-Up. J Clin Periodontol. 2026;53:933-46.

77. Dionigi C, Regidor E, Trullenque-Eriksson A, Derks J, Sanz M, Ortiz-Vigón A. The Use of a Resorbable Membrane as an Adjunct to a Xenogeneic Bone Replacement Graft in the Reconstructive Surgical Therapy of Peri-Implantitis: 3-Year Results of a

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Randomised Clinical Trial. J Clin Periodontol. 2026;53:268-85.

78. Romandini M, Bougas K, Alibegovic L, Hosseini S, Carcuac O, Berglundh T, Derks J. Long-term outcomes and prognostic factors of surgical treatment of peri-implantitis - A retrospective study. Clin Oral Implants Res. 2024;35:321-9

Peri-implantitis'i Yeniden Düşünmek: Etiyolojik Heterojenite, Bireyselleştirilmiş Tedavi ve Uzun Dönem Hastalık Kontrolü

ÖZET

Peri-implantitis, belirgin etiyolojik heterojenite ve değişken tedavi sonuçları ile karakterize, biyofilm aracılı inflamatuvar bir hastalıktır. Hastalığın gelişiminin; mikrobiyal disbiyoz ve konak duyarlılığının, bazıları implant tedavisi sürecinde ortaya çıkabilen lokal anatomik, implantla ilişkili, protetik ve bakım ile ilişkili faktörlerle etkileşimini yansıttığı düşünülmektedir. Bu narratif derleme, peri-implantitisin başlangıcı ve ilerlemesi ile ilişkili faktörlere ilişkin güncel kanıtları özetlemekte ve bu faktörlerin korunma, tanı ve tedavi planlaması açısından klinik önemini değerlendirmektedir. Özellikle başlangıç cerrahi olmayan hastalık kontrolü, değiştirilebilir faktörlerin düzeltilmesi, implant yüzeyinin dekontaminasyonu ve korunması, cerrahi tedavi endikasyonları, defekt özelliklerine göre rekonstrüktif ve rezektif yaklaşımlar ile implantoplastinin seçici kullanımını içeren basamaklı tedavi yaklaşımına odaklanılmaktadır. Uzun dönem sonuçlar ayrıca rezidüel hastalık aktivitesi, hastalık nüksü riski ve destekleyici peri-implant bakım ile ilişkili olarak ele alınmaktadır. Güncel kanıtlar, tedavi yoğunluğunun hastalık şiddeti, defekt konfigürasyonu, implant yüzeyi ekspozisyonu ve hastaya özgü duyarlılığa göre uyarlandığı bireyselleştirilmiş ve risk temelli bir yaklaşımı desteklemektedir. Tedavi başarısının uzun dönemde sürdürülebilmesi, inflamasyonun ve ilerleyici kemik kaybının yapılandırılmış destekleyici peri-implant bakım (SPIC) kapsamında sürekli olarak kontrol altında tutulmasına bağlıdır.

Anahtar Kelimeler: Biyofilm; İdame tedavisi; Keratinize mukoza, Komplikasyon; Peri-implantitis, Rekonstrüktif tedavi

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Original Research Article

Effects of Different Activation and Obturation Techniques on the Depth of Root Canal Sealer

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ABSTRACT

Aim: The successful outcome of root canal treatment is contingent upon establishing a three-dimensional seal that encompasses the obturation of lateral and accessory canals. This study investigated the impact of different activation strategies and obturation techniques on the depth of sealer penetration in simulated lateral canals.

Materials and Methods: 3D-printed resin-based 120 maxillary central tooth models with standardized lateral canals at the middle level of the root. The prepared canals were categorized into twelve groups, including 10 samples in each group. AH Plus sealer was placed into the canals. EDDY, EndoActivator, and passive ultrasonic activation were applied to experimental groups, and one group did not undergo activation. Then, canals were filled with single cone, warm vertical compaction, and cold lateral compaction techniques. Periapical radiographs were taken using the parallel technique. Penetration depths were measured in ImageJ software. In statistical analyses, two-way ANOVA and where significant differences were observed, Tukey's HSD and Bonferroni post hoc tests were applied ($p < 0.05$).

Results: Two-way ANOVA analysis demonstrated that the activation technique had a statistically significant effect. The post-hoc comparisons revealed that all activation techniques resulted in significantly deeper penetration compared to the control group. The ultrasonic activation demonstrated significantly greater penetration compared to the EndoActivator and EDDY groups ($p < 0.05$). There was no statistically significant difference between the EndoActivator and EDDY groups. The obturation technique had no significant main effect. No significant difference was observed among the three canal obturation techniques ($p > 0.05$).

Conclusion: While the obturation technique did not affect sealer penetration, sealer activation resulted in significantly increased penetration into lateral canals.

Keywords: Root canal anatomy; Root canal obturation; Ultrasonics

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INTRODUCTION

Root canal therapy is the primary approach for managing pulp and periapical diseases. It involves debridement, shaping, and obturation of the root canal system[1], known for its complex structure.[2] Lateral canals are defined as accessory canals that extend from the main canal toward the periodontal ligament.[3] These canals have a large enough surface area to accommodate numerous microorganisms.[4] The etiology of combined endodontic-periodontal lesions has been associated with lateral canals.[5] Optimal sealing of root canal obturation materials into lateral canals and irregular areas is crucial for achieving a thorough three-dimensional and hermetic seal.[6]

Activation protocols can help root canal sealers penetrate dentinal tubules more effectively, thereby improving their sealing ability and antimicrobial efficacy.[7] In endodontics, sonic and ultrasonic devices that produce oscillatory motion are used as activation systems.[8] Sonic devices operate at frequencies between 1500 and 6000 Hz[9], whereas ultrasonic devices require vibrations higher than 20000 Hz.[10] A widely used sonic agitation device is the EndoActivator system (Dentsply Tulsa Dental Specialties, Tulsa, OK, USA), which incorporates a portable

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handpiece and three non-cutting, flexible polymer tips in different sizes.[11] The EDDY system (VDW, Munich, Germany) is another sonic system that utilises high-frequency sonic oscillation at 6,000 Hz.[12] It uses polyamide tips of a single size (i20/02), which are more flexible than rigid metal tips. According to the manufacturer, EDDY tips exhibit a three-dimensional motion with high amplitude.[13] Passive ultrasonic activation is the non-cutting action of an ultrasonically activated tip, which is a non-invasive approach.[14]

Cold lateral compaction is a frequently used root canal obturation technique that provides predictably accurate length control.[15] In the single-cone root canal obturation technique, main gutta-percha points are selected to precisely match the taper, apical diameter, and overall dimensions of the final shaping file.[16] Schilder[17] introduced the warm vertical compaction technique as another method for obturation of root canals. It has been reported to provide a more homogeneous obturation with fewer voids, particularly in oval-shaped main canals. Therefore, this study aimed to compare how different combinations of activation systems and root canal obturation techniques affect the extent of sealer penetration into lateral canals.

The null hypothesis of this study was that there was no statistically significant difference in the depth of penetration of the sealer into the lateral canals among different combinations of activation and root canal obturation techniques.

MATERIALS AND METHODS

Sample Preparation

A total of 120 maxillary central tooth models with single canal anatomy were used in experimental procedures. The 3D tooth models were designed using Cura Slicing Software (Ultimaker, Netherlands). Each model included a lateral canal with a diameter of 0.3 mm extending from the main root canal to the external root surface, positioned at 7 mm from the apex. Each model had a total length of 25 mm, consisting of a 10-mm crown and a 15-mm root. The root canal had an apical diameter of 0.8 mm and a straight configuration with no canal curvature (0°). The models were fabricated from resin material using Stereolithography 3D printing technology. The sample size was determined through an a priori power analysis performed using G*Power 3.1 software (Franz Faul, University of Kiel, Kiel, Germany). With a total sample size of 120 (n = 10 per group), an alpha level of 0.05, and a statistical power of 0.80, the analysis indicated that the study could detect an effect size of Cohen's f = 0.25 (medium effect).

Working length determination was performed by inserting a #10 K-file into the canal until visual confirmation of its tip at the apical foramen was achieved. To establish the working length, 1 mm was subtracted from the length at which the file tip became visible at the apical foramen. Subsequently, the canals were prepared using a rotary file system with a 25 apical tip size and 0.06 taper (Revo S, Micro-Mega, Besançon, France). Between each instrumentation, irrigation was performed with 2.5% sodium hypochlorite (Cerkamed, Stalowa Wola, Poland). Upon completion of instrumentation, canal drying was performed with paper points (Diadent Group International, Cheongju, South Korea). All specimens were then randomly divided into experimental groups (n=10). The specimens were randomly divided into four main groups based on the sealer activation protocol (three activation techniques and one no-activation control), and each main group was subsequently divided into three subgroups according to the root canal obturation technique, resulting in a total of 12 experimental groups. A single experienced operator performed all obturation procedures to eliminate inter-operator variability.

After grouping, AH Plus sealer (Dentsply DeTrey, Germany) was prepared according to the manufacturer's instructions. To standardize the amount of sealer placed in each canal, an equal quantity of sealer was coated onto a size 25/.06 gutta-percha cone and introduced into the root canal. Following sealer placement, sealer activation was performed using three different activation methods.

1) EndoActivator Activation: A tip (25/04, Dentsply Maillefer, Ballaigues, Switzerland) was fitted to the EndoActivator handpiece.

2) EDDY activation: A polyamide EDDY tip (25/06, VDW, Munich, Germany) was attached to a TA-200 sonic device (Micron, Tokyo, Japan), which was set to 6000 Hz.

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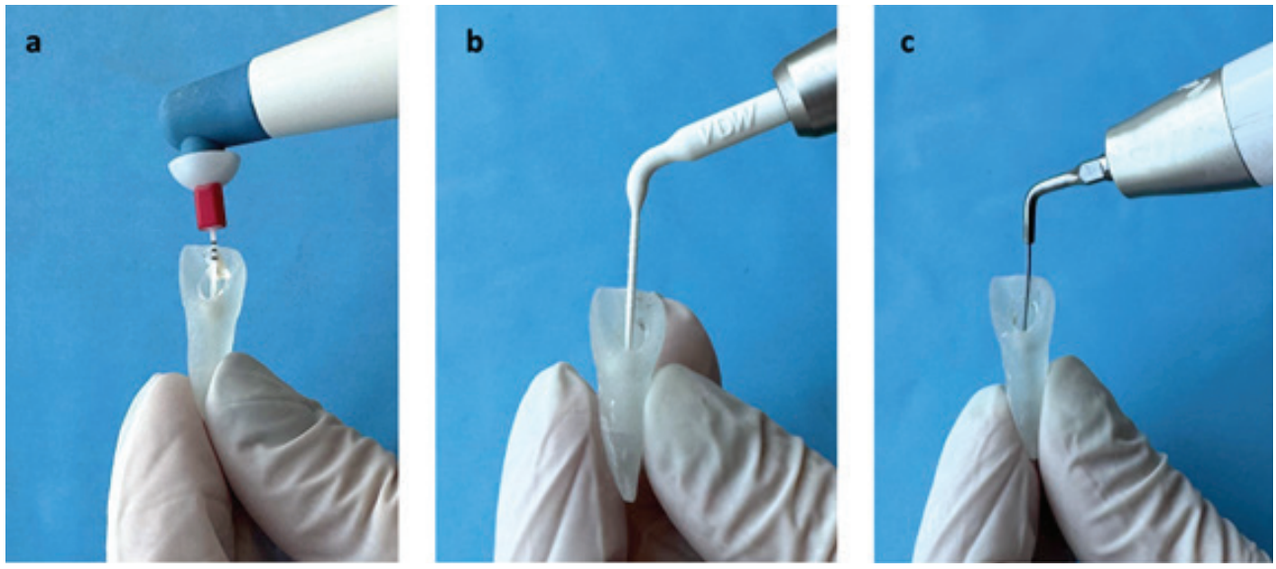


Figure 1. The images show activation systems during sealer activation: a: Endoactivator, b: EDDY, c: passive ultrasonic .

3) Passive Ultrasonic Activation: An ED93 ultrasonic tip (Guilin Woodpecker Medical Instrument Co., Guilin, China) was attached to the DTE S6 ultrasonic device (Guilin Woodpecker Medical Instrument Co., Guilin, China).

In all groups, the chosen tip was placed 2 mm short of the working length, and activation was performed for 20 seconds in two consecutive cycles to facilitate sealer adaptation to the root canals, as in a previous study.[18] Figure 1 shows sonic and ultrasonic tips in the root canal during sealer activation.

The three obturation methods used were:

1) Single Cone: A size-matched F3 gutta-percha cone (Pearl Endo, Pearl Dent Co., South Korea) was used with AH Plus sealer. Following the activation of the sealer, root canal obturation was performed. A gutta-percha cone was inserted to the full working length. The surplus gutta-percha was removed with a heated plugger, and the access cavities were restored provisionally using a temporary filling material.

2) Cold Lateral Compaction: After a master gutta-percha cone (size 25/02) (Pearl Endo, Pearl Dent Co., South Korea) was placed into the canal, followed by the insertion of accessory cones using finger spreaders to achieve lateral compaction. The surplus gutta-percha was removed with a heated plugger, and the access cavities were restored provisionally using a temporary filling material.

3) Warm Vertical Compaction: Gutta-percha was thermoplastically compacted in incremental steps using a heated plugger. Prior to compaction, the medium-sized plugger of the down-pack device (Fast Pack Pro, Eighteeth, China) was inserted up to the apical 4 mm of the canal. AH Plus sealer (Dentsply, Konstanz, Germany) was mixed and introduced into the canal along with a size F3 gutta-percha cone (Pearl Endo, Pearl Dent Co., South Korea). Backfilling of the canal was then completed using the Fast Fill device (Eighteeth, Changzhou, China).

Imaging and Measurements

Using the parallel technique, radiographic images of the teeth were acquired utilizing periapical radiography with a Gendex Expert (KaVo Kerr, New York, USA) device. The samples were fixed on a flat surface with the buccal surfaces facing upward and irradiated perpendicularly. The depth of sealer infiltration within the artificial lateral canals was quantitatively assessed using the measurement features of ImageJ software (version 2.0.0-rc43/1.51e, National Institutes of Health, Bethesda, USA). Figure 2 demonstrates a measurement tool in a lateral canal. All measurements of sealer penetration depth were performed twice by a single experienced endodontist, with a two-week interval. For the statistical analysis, the second set of measurements was used. This choice was made to reflect a more stable and consistent measurement process, as increased familiarity with the evaluation criteria and software

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tools was assumed to have been achieved by the examiner during the second round. Although averaging the two sets was considered, a single consistent dataset was preferred in order to preserve the natural variability of the measurements without artificial smoothing.



Figure 2. The figure demonstrates the use of the measurement tool in ImageJ to measure the penetration depth of a lateral canal.

Statistical analysis

Statistical analyses were conducted using Jamovi software (Jamovi Project, ver. 2.6.44, Sydney, Australia). Prior to the main analyses, the assumptions of normality and homogeneity of variances were evaluated. Normal distribution of the data was verified using the Shapiro–Wilk test, and homogeneity of variances was confirmed using Levene's test. Then, two-way ANOVA was performed to assess the effects of activation and obturation techniques, as well as their interaction, on sealer penetration depth. Where significant differences were observed ($p < 0.05$), Tukey's HSD and Bonferroni post hoc tests were applied. Intra-examiner reliability was assessed using the intraclass correlation coefficient (ICC) based on two sets of measurements.

RESULTS

The intra-examiner reliability was assessed using a two-way mixed-effects model for absolute agreement. The ICC was found to be 0.94, indicating excellent reliability between the two sets of measurements. Table 1 shows the mean penetration depths of the sealers at all levels of the experimental groups. Levene's test confirmed homogeneity of variances across groups ($p = 0.06$), and the Shapiro-Wilk test showed that the data were approximately normally distributed ($p = 0.06$). Table 2 indicates the two-way ANOVA test results. The activation technique had a statistically significant effect on lateral canal penetration depth, whereas the canal obturation technique showed no significant effect. No significant differences were observed between the three canal

Table 1. The mean values of sealer penetration depth according to groups (mm)

		Mean	SD
No activation	**Single cone**	1.82	0.05
	Cold lateral compaction	1.27	0.04
	Warm vertical compaction	0.95	0.02
EndoActivator	**Single cone**	2.52	0.03
	Cold lateral compaction	2.30	0.05
	Warm vertical compaction	1.94	0.03
EDDY	**Single cone**	2.20	0.01
	Cold lateral compaction	2.12	0.01
	Warm vertical compaction	2.22	0.01
Ultrasonic	**Single cone**	3.00	0.01
	Cold lateral compaction	2.93	0.02
	Warm vertical compaction	3.00	0.01

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obturation techniques (p=0.32). No significant interaction was observed between activation and obturation techniques (p=0.86).

The post-hoc comparisons revealed that sonic and ultrasonic activation techniques resulted in significantly deeper penetration compared to the control group (p<0.05). The ultrasonic activation demonstrated significantly greater penetration compared to the EndoActivator and EDDY groups (respectively, p=0.045, p=0.02). There was no statistically significant difference between the EndoActivator and EDDY groups (p=0.99).

Table 2. Two-way ANOVA results of all levels

	Sum of Squares	df	Mean Square	F	p
Activation	17.8	3	5.92	11.06	<.001
Filling technique	1.2	2	0.62	1.16	0.32
Activation ✻ filling technique	1.4	6	0.23	0.43	0.86

DISCUSSION

The lateral canal spaces, if not filled, can become a nutritional source for bacteria, leading to leakage and, consequently, the penetration and colonisation of the root canal by microbes.[19] To prevent reinfection, it is essential to achieve a tight seal of the root canals, including the thorough obturation of both the main and lateral canals.[20] Several studies have proposed the use of sonic or ultrasonic activation techniques to improve the adaptation and obturation quality of endodontic sealers within the root canal system.[21,22] Therefore, this study evaluated the effectiveness of different activation and root canal obturation techniques on sealer penetration to lateral canals. A maxillary central tooth model with lateral canals in the middle third of the root canal was designed and produced using a 3D printer.

Researchers have extensively utilised extracted human teeth in *in vitro* studies. However, there are some disadvantages to consider, including ethical concerns and the challenges associated with collecting and standardising human tooth samples with similar characteristics for *in vitro* analysis.[23] It is challenging to acquire teeth that possess similar characteristics, particularly those with lateral canals, or to generate such features in extracted teeth.[24] The use of 3D printing technology facilitates the production of resin-based tooth models. They can be designed to fully simulate the internal and external morphology of natural teeth in a standardised manner.[23] This innovative approach allows the design of samples in various sizes and degrees of curvature, with features such as reproducibility and repeatability.[25]

The null hypothesis was rejected because there was a statistically significant difference between the groups in terms of the depth of penetration of the sealer into the lateral canals. According to the findings, the activation technique had a statistically significant impact on lateral canal penetration depth. Ultrasonic activation showed the highest penetration depth of the root canal sealer into the lateral canal. Similarly, Arslan *et al*. reported that using ultrasonic activation with a sealer enhanced its penetration into the lateral canals.[22] There was no significant difference between Endoactivator and EDDY, but a higher penetration depth was observed than in the control group. Considering the properties of root canal sealer, its activation may increase the penetration of the sealer into canal irregularities.[26] The present results are consistent with this knowledge and reveal that ultrasonic oscillation is more effective than sonic systems.

The type of canal obturation technique did not produce a significant effect. Furthermore, no significant interaction was found between the activation and obturation techniques. The absence of significant differences among the obturation techniques suggests that the method of obturation may play a limited role in influencing the depth to which the sealer penetrates lateral canals. Demir *et al*.[27] reported that different obturation techniques did not significantly differ in sealer penetration into dentinal tubules. Factors such as sealer properties and activation methods may influence lateral canal penetration more than the mechanical compaction technique itself.[27-29] Furthermore, the anatomical complexity of lateral canals may limit the effectiveness of different obtu-

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ration techniques in achieving deeper sealer penetration. [30] In the present study, sonic systems were less effective than ultrasonic activation in promoting sealer penetration. This highlights the importance of enhancing sealer flow and activation, rather than relying solely on the obturation method. High-frequency ultrasonic vibrations have been reported to enable deeper penetration of obturation materials into complex canal anatomies.[31] Coşkun *et al*.[32] reported that ultrasonic activation enhances the flow of obturation materials. Previous studies also reported that ultrasonic activation reduces microleakage, improves bond strength, and increases the overall quality of the obturation.[33,31] Karataşlioğlu and Tosun study[34] showed that ultrasonic and XP-Endo Finisher activation significantly increased sealer penetration, particularly for MTA Fillapex but not for AH Plus. This comparison supported that the sealer material type can be significantly affected by activation methods.

The findings of the study demonstrated that the application of ultrasonic tips to activate the root canal sealer enhanced its penetration into the lateral canals. Therefore, ultrasonic sealer activation may be beneficial for improving sealing under clinical conditions. The findings of a previous meta-analysis revealed that ultrasonic activation promotes significant cohesion between obturation materials and dentinal tubules, thereby reducing the risk of apical leakage.[35] Although ultrasonic devices have been used in endodontics for many years, factors such as equipment cost, device availability in clinics, practitioner training, and the impact on procedure time should be taken into consideration to ensure clinical accessibility.

A limitation of the present study is the use of 3D-printed tooth models, which, despite providing highly standardized specimens, do not completely replicate the structural and physicochemical characteristics of natural dentin. Therefore, the findings should be interpreted within the context of the current *in vitro* study design. On the other hand, another limitation is that periapical radiography represents a three-dimensional structure in only two dimensions. It can lead to overlooking the void in lateral canal filling. To minimize this limitation, radiographs were taken using the parallel technique under fixed parameters, and penetration depth was measured based on the obtained images.

Unlike the methodology of previous studies, the sealer reaching the lateral canals was scored more quantitatively by measuring the depth instead. Previous studies have generally assessed sealer penetration into lateral canals using qualitative or semi-quantitative scoring based on visual methods like stereomicroscope images, radiographic images, or photographs.[22,30,35,37] In contrast, the present study employed a quantitative approach by directly measuring the linear penetration depth of the sealer within lateral canals of standardized length, thereby allowing more objective and reproducible comparisons between groups. To date, no universally accepted gold-standard method exists for evaluating sealer penetration into lateral canals *in vitro*. Micro-computed tomography (micro-CT) is increasingly regarded as the most accurate method due to its volumetric nature.[38] In future studies, 3D imaging methods, such as micro-CT, which allows volumetric analysis, can be used to evaluate the amount and volume of material reaching the lateral canals.

CONCLUSIONS

All activation techniques showed more sealer penetration depth compared to the non-activation group. Ultrasonic activation significantly enhanced sealer penetration into lateral canals, higher than sonic systems. The depth of sealer penetration into lateral canals remained unaffected by the obturation technique employed, whether it was single-cone, lateral compaction, or warm vertical compaction.

ETHICAL APPROVAL

Ethical approval was not required for this study as it did not involve any animal or human subjects.

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None

CONFLICT OF INTEREST

There is no conflict of interest related to the study.

REFERENCES

1. Retsas A, Dijkstra RJB, van der Sluis L, Boutsioukis C. The Effect of the ultrasonic irrigant activation protocol on the removal of a dual-species biofilm from artificial lateral canals. J Endod 2022;48:775-80.

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2. Ahmed HMA, Versiani MA, De-Deus G, Dummer PMH. A new system for classifying root and root canal morphology. Int Endod J 2017;50:761-70.

3. American Association of Endodontists. Glossary of Endodontic Terms. 10th ed. Chicago: AAE; 2020. Available from: https://www.aae.org/specialty/clinical-resources/glossary-endodontic-terms/

4. Ricucci D, Siqueira Jr JF. Fate of the tissue in lateral canals and apical ramifications in response to pathologic conditions and treatment procedures. J Endod 2010;36:1-15.

5. Al-Fouzan KS. A new classification of endodontic-periodontal lesions. Int J Dent 2014:919173.

6. Wolf TG, Willems L, Briseño-Marroquín B. An in vitro endodontic model to quantify the accessory canal filling potential of the vertical and lateral condensation techniques. Aust Endod J 2021;47:245-51.

7. Guimarães BM, Amoroso-Silva PA, Alcalde MP, Marciano MA, de Andrade FB, Duarte MA. Influence of ultrasonic activation of 4 root canal sealers on the filling quality. J Endod 2014;40:964-8.

8. Nusstein JM. Endodontic sonic and ultrasonic irrigant activation. Clin Dent Rev 2018;2:22.

9. Plotino G, Grande NM, Mercade M, Cortese T, Staffoli S, Gambarini G, *et al*. Efficacy of sonic and ultrasonic irrigation devices in the removal of debris from canal irregularities in artificial root canals. J Appl Oral Sci 2019;27:e20180045.

1**0.** Mohammadi Z, Shalavi S, Giardino L, Palazzi F, Asgary S. Impact of ultrasonic activation on the effectiveness of sodium hypochlorite: A Review. Iran Endod J 2015;10:216-20.

11. Adl A, Razavian A, Eskandari F. The efficacy of EndoActivator, passive ultrasonic irrigation, and Ultra X in removing calcium hydroxide from root canals: an in-vitro study. BMC Oral Health 2022;22:564.

12. Liu C, Li Q, Yue L, Zou X. Evaluation of sonic, ultrasonic, and laser irrigation activation systems to eliminate bacteria from the dentinal tubules of the root canal system. J Appl Oral Sci 2022;30:e20220199.

13. Chu X, Feng S, Zhou W, Xu S, Zeng X. Cleaning efficacy of EDDY versus ultrasonically-activated irrigation in root canals: a systematic review and meta-analysis. BMC Oral Health 2023;23:155.

14. Gomes BPFA, Aveiro E, Kishen A. Irrigants and irrigation activation systems in Endodontics. Braz Dent J 2023;34:1-33.

15. Winkler A, Adler P, Ludwig J, Hofmann N, Soliman S, Krastl G, *et al*. Endodontic outcome of root canal treatment using different obturation techniques: A Clinical Study. Dent J 2023;11:200.

16. Cho Y-S, Kwak Y, Shin S-J. Comparison of root filling quality of two types of single cone-based canal filling methods in complex root canal anatomies: The ultrasonic vibration and thermo-hydrodynamic obturation versus single-cone technique. Materials 2021;14:6036.

17. Keleş A, Keskin C. Presence of voids after warm vertical compaction and single-cone obturation in band-shaped isthmuses using micro-computed tomography: A phantom study. Microsc Res Tech 2020;83:370-4.

18. da Silva Machado AP, Câncio Couto de Souza AC, Lima Gonçalves T, Franco Marques AA, da Fonseca Roberti Garcia L, Antunes Bortoluzzi E, et al. Does the ultrasonic activation of sealer hinder the root canal retreatment? Clin Oral Investig 2021;25:4401-6.

19. Siqueira Jr JF, Rôças IN. Treatment of endodontic infections. Quintessenz Verlag.2022

20. Tait C, Camilleri J, Blundell K. Non-surgical endodontics-obturation. Br Dent J 2025;238:487-96.

21. Kim JA., Hwang YC, Rosa V, Yu MK, Lee KW, Min KS. Root canal filling quality of a premixed calcium silicate endodontic sealer applied using gutta-percha cone-mediated ultrasonic activation. J Endod 2018;44:133-8.

22. Arslan H, Abbas A, Karatas E. Influence of ultrasonic and sonic activation of epoxy-amine resin-based sealer on penetration of sealer into lateral canals. Clin Oral Investig 2016;20:2161-4.

23. Cui Z, Wei Z, Du M, Yan P, Jiang H. Shaping ability of protaper next compared with waveone in late-model three-dimensional printed teeth. BMC Oral Health. 2018;18:115

24. Hülsmann, M. A critical appraisal of research methods and experimental models for studies on root canal preparation. Int Endod J 2022;55:95-118.

25. Cresswell-Boyes AJ, Davis GR, Krishnamoorthy M, Mills D, Barber AH. Composite 3D printing of biomimetic human teeth. Sci Rep 2022;12:7830.

26. Pauletto G, Padoin Y, de Pellegrin SF, Bier CAS. The use of sonic and ultrasonic activation of endodontic sealer to improve sealer filling quality in the root canal: a scoping review. Odontology 2024;112:657-71.

27. Demir E, Kamalı SG, Türkaydın D. Effect of different obturation techniques on sealer penetration into dentinal tubules after final irrigation with XP-Endo Finisher file. Odovtos-Int J Dent Sc 2023;25:30-9.

28. El Sayed M. Penetration of three endodontic sealers in simulated lateral canals during the lateral condensation technique: An In Vitro Study. Int J Dent 2022;2022:2686247.

29. Ko SY, Choi HW, Jeong ED, Rosa V, Hwang YC, Yu MK, *et al*. Main and accessory canal filling quality of a premixed calcium silicate endodontic sealer according to different obturation techniques. Materials (Basel) 2020;13:4389.

30. Goldberg F, Artaza LP, De Silvio A. Effectiveness of different obturation techniques in the filling of simulated lateral canals. J Endod 2001;27:362-4.

31. Li JN, Yi HN, Yang FN, Miao L, Du QT, Du XP. Effect of ultrasonic-assisted iRoot SP single-cone technique on root canal filling efficacy: An *in vitro* study. Am J Transl Res 2025;17:4375-86.

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32. Coşkun Başoğlu E, Koçak S, Özdemir O, Koçak MM, Sağlam BC. Efficacy of various activation techniques on tubule penetration of resin-based and bioceramic root canal sealers: an *in vitro* confocal microscopy study. Aust Endod J 2023;49:381-9.

33. Vin SP, Singh SH, Podar RS, Kulkarni GP, Lokhande AM, Chandekar SV. An *in vitro* comparative evaluation of push-out bond strength of three root canal sealers using sonic and ultrasonic activation. J Conserv Dent Endod 2025;28:1285-91.

34. Karataşlioğlu E, Tosun S. Effect of different sealer placement and activation techniques on sealer penetration depth and penetration area. Microsc Res Tech 2025;88:2878-85.

35. Paixao S, Rodrigues C, Grenho L, Fernandes MH. Efficacy of sonic and ultrasonic activation during endodontic treatment: a meta-analysis of *in vitro* studies. Acta Odontol Scand 2022;80:588-95.

36. da Silva DP, Silva IMR, Falcao LF, Falcao DF, Ferraz MÁA, Falcao CAM. Penetration degree of sealer in artificial lateral canal after passive ultrasonic irrigation with EDTA for different times. Acta Odontol Latinoam 2019;32:51-6.

37. Chan AYY, Chang JWW, Cheung GSP, Neelakantan P, Zhang C, Lee AHC. Penetration of Calcium Silicate and Epoxy Resin Sealers Into the Lateral Canals. Int Dent J 2024;74:762-8.

38. Chen Z, Chen N, Yang Y, Fan W. Micro-computed tomographic evaluation on the quality of single-cone obturation using a modified passive-deflation sealer injection needle: an *in vitro* study. BMC Oral Health 2024;24:476.

Farklı Aktivasyon ve Obturasyon Tekniklerinin Kök Kanal Patının Lateral Kanallara Penetrasyon Derinliğine Etkisi

ÖZET

Amaç: Kök kanal tedavisinin sonucunun başarılı olması, lateral ve aksesuar kanalların doldurulmasını kapsayan üç boyutlu bir sızdırmazlığın sağlanmasına bağlıdır. Bu çalışmada, simüle edilmiş lateral kanallarda, farklı aktivasyon stratejileri ve obturasyon tekniklerinin kanal dolgu patıının penetrasyon derinliği üzerindeki etkisi incelenmiştir.

Gereç ve Yöntemler: Kökün orta bölümünde standart lateral kanallara sahip, 3 boyutlu baskı ile üretilmiş rezin bazlı 120 maksiller santral diş modeli kullanıldı. Örnekler her grupta 10 örnek olmak üzere on iki gruba ayrıldı. Kanallara AH Plus kanal dolgu maddesi yerleştirildi. Deney gruplarına EDDY, EndoActivator ve pasif ultrasonik aktivasyon uygulandı ve bir gruba aktivasyon uygulanmadan ayrıldı. Ardından, kanallar tek kon, sıcak vertical kompaksiyon ve soğuk lateral kompaksiyon teknikleriyle dolduruldu. Paralel teknik kullanılarak periapikal radyografiler alındı. Lateral kanallardaki penetrasyon derinlikleri ImageJ yazılımında ölçüldü. İstatistiksel analizlerde iki yönlü ANOVA kullanıldı ve anlamlı farklılıklar gözlemlendiğinde Tukey'nin HSD ve Bonferroni post hoc testleri uygulandı ($p < 0.05$).

Bulgular: İki yönlü ANOVA analizi, aktivasyon tekniğinin istatistiksel olarak anlamlı bir etkiye sahip olduğunu göstermiştir. Post-hoc karşılaştırmalar, tüm aktivasyon tekniklerinin kontrol grubuna kıyasla anlamlı derecede daha derin penetrasyon sağladığını ortaya koydu. Ultrasonik aktivasyon, EndoActivator ve EDDY gruplarına kıyasla anlamlı derecede daha fazla penetrasyon gösterdi ($p < 0.05$). EndoActivator ve EDDY grupları arasında istatistiksel olarak anlamlı bir fark görülmedi. Obturasyon tekniğinin anlamlı bir ana etkisi yoktu. Üç kanal dolgu tekniği arasında anlamlı bir fark gözlenmedi ($p > 0.05$).

Sonuç: Obturasyon tekniği kanal dolgusunun penetrasyonunu etkilemezken, kök kanal patının aktivasyonu lateral kanallara penetrasyonda anlamlı derecede artışa neden oldu.

Anahtar Kelimeler: Kök kanal anatomisi; Kök kanal dolgusu; Ultrasonik

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Original Research Article

Evaluation of Dental Students' Self-Efficacy Regarding Root Canal Treatment Performance: A Survey Study

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ABSTRACT

Aim: Assessing undergraduate dental students' self-efficacy can help educators better understand what works well in the curriculum and where further support is needed. This study aimed to explore differences in undergraduate dental students' self-efficacy in performing root canal treatments according to academic year and gender.

Materials and Methods: A survey was conducted among fourth- and fifth-year students from eight dental faculties in Ankara, Türkiye, all of whom had completed their endodontic clinical practice. The questionnaire consisted of demographic questions and items assessing students' self-efficacy in performing different steps of root canal treatment. Responses were rated on a 5-point Likert scale (1 = not sufficient, 5 = very sufficient). The internal consistency of the questionnaire was assessed using Cronbach's alpha, and a linear-by-linear Chi-squared test was applied to evaluate trends across ordered Likert-scale responses between academic year and gender. Statistical significance was set at $p < 0.05$.

Results: A total of 135 students participated in the study, including 44 (32.6%) males and 91 (67.4%) females. Among them, 48 (35.6%) were fourth-year and 87 (64.4%) were fifth-year students. Descriptive analysis showed that students' self-efficacy levels were generally in the neutral to high range across most endodontic procedures. Fifth-year students reported higher self-efficacy than fourth-year students for indication, single versus multiple visits, infiltrative anesthesia, access cavity, localization of canal orifices in anterior and premolar teeth, irrigation, and working length maintenance ($p < 0.05$), while no such trend was observed for the remaining procedures ($p > 0.05$). No linear trend was observed between gender and self-efficacy levels, except for access cavity, preparation, and periapical radiography ($p < 0.05$).

Conclusion: Overall, students generally had a moderate to high perception of self-efficacy, with differences across academic years and gender confined to a limited number of endodontic procedures.

Keywords: Dental students; Endodontics; Self-efficacy; Survey study

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INTRODUCTION

Undergraduate dental students are required to gain clinical experience during their training.[1] With increasing clinical exposure, students' performance tends to improve[2], and hands-on experience not only reinforces their learning but also contributes to patient care.[3] In addition, students' performance is strongly influenced by their self-efficacy.[4-6] Moreover, self-efficacy substantially contributes to students' academic achievement, as it has been shown to influence the effectiveness with which individuals perform tasks.[6]

In undergraduate dental education, the quality of endodontic procedures performed by students is widely recognized as a reliable indicator of clinical competence and serves as an essential measure for evaluating their overall proficiency.[7] Among the various

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dental specialties, endodontic procedures are often perceived by students as a challenging task and associated with higher stress levels compared to periodontology and restorative dentistry.[8] Multiple factors contribute to this perception, such as the need for effective patient communication, emergency management, pain control, the use of various techniques and materials, anatomical variations, and the overall complexity of endodontic procedures.[5] These challenges can increase students' stress and this may undermine students' self-efficacy in performing root canal treatments.[9]

After graduation, dental professionals should be able to accurately diagnose endodontic conditions and develop effective treatment strategies to provide high-quality patient care.[3] To achieve this, it is essential that the curriculum be regularly reviewed. Understanding dental students' views on their educational experiences plays a critical role in the curriculum planning processes of dental schools and can inform improvements that promote more effective learning. Thus, achieving both solid theoretical knowledge and sufficient clinical experience enables students to perform endodontic procedures independently and confidently.[8-11]

Self-efficacy describes a person's belief in their own competence and confidence in carrying out specific tasks successfully. It positively influences clinical endodontic performance[4] and is linked to the effective use of academic skills.[12] Furthermore, individuals with high self-efficacy tend to show greater persistence and are better able to perform effectively in stressful situations compared with those who have low self-efficacy.[13] Dental curricula are designed around specific competencies that students must achieve to practice independently after graduation.[14] However, not all graduates feel confident in their abilities.[15,16]

Until now, many studies have examined students' self-confidence regarding various stages of endodontic treatment[8, 17-20], few have explored this issue from the perspective of self-efficacy.[4, 6] To better understand self-efficacy and its link to undergraduate education, it would be valuable to examine students' self-efficacy in various endodontic programs as well.[21] Therefore, this study aims to evaluate the self-efficacy levels of fourth- and fifth-year undergraduate dental students at faculties of dentistry in Ankara for various stages of root canal treatment. The null hypothesis was that there would be no statistically significant differences in self-efficacy levels according to academic year or gender.

MATERIALS AND METHODS

Ethical approval was obtained from the Ethics Committee of Ankara University (Decision No: 06/54, dated 03.04.2024). An a priori power analysis was performed using G*Power (version 3.1.9.7; Universität Düsseldorf, Germany). In the absence of prior studies using the same measurement instrument, study design, and target population, a medium effect size ($d_z = 0.50$) was assumed based on Cohen's conventional benchmark for a standardized mean-difference effect.[22] This value represents a deliberately conservative assumption and is considered appropriate when no directly comparable prior estimate is available. With a significance level of $\alpha = 0.05$ and a desired power of $1 - \beta = 0.90$, the required minimum sample size was calculated as 130 participants.

The survey included demographic items and was designed to evaluate students' self-efficacy levels across various stages of endodontic procedures. The survey instrument was developed by adapting from the Endodontic General Self-Efficacy Scale.[21] The original scale comprises 10 items assessing students' generalized sense of self-efficacy in endodontic practice on a 4-point response scale. As the aim of the present study was to assess self-efficacy at the level of specific procedural steps rather than as a global construct, the items were substantially adapted to reflect discrete clinical stages of root canal treatment: indication, anesthesia, isolation, access cavity, working length, irrigation, obturation, management and prediction of complications, post-endodontic restoration, and periapical radiography. The response format was modified to a 5-point Likert scale (1 = not sufficient, 2 = slightly sufficient, 3 = neutral, 4 = sufficient, 5 = very sufficient). The adapted instrument comprised 19 items in total, and the English translation of all statements is presented in Table 1. The adapted items were examined by experienced endodontic specialists for clinical accuracy, scope, and contextual appropriateness within the Turkish dental education system; necessary revisions were made based on their feedback.

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Table 1. Statements used to assess students' self-efficacy in performing various endodontic procedures. Responses were rated on a 5-point Likert scale (1 = not sufficient, 5 = very sufficient)

Endodontic Procedure	Statement
Indication	I am confident that I can decide on the indication for endodontic treatment.
Single vs multiple visits	I am confident that I can determine whether endodontic treatment should be completed in a single visit or over multiple visits.
Infiltrative anesthesia	I am confident that I can administer infiltration anesthesia.
Block anesthesia	I am confident that I can perform inferior alveolar nerve block anesthesia.
Intrapulpal anesthesia	I am confident that I can apply intrapulpal anesthesia.
Isolation	I am confident that I can achieve proper isolation.
Access cavity	I am confident that I can establish appropriate access cavity during endodontic treatment.
Localization of orifices (anterior teeth)	I am confident that I can locate root canal orifices in anterior teeth.
Localization of orifices (premolar teeth)	I am confident that I can locate root canal orifices in premolar teeth.
Localization of canal orifices (posterior teeth)	I am confident that I can locate root canal orifices in molar teeth.
Preparation	I am confident that I can perform the mechanical preparation of root canals effectively.
Periapical radiograph	I am confident that I can take accurate periapical radiographs.
Working length determination	I am confident that I can determine the working length correctly.
Maintaining the working length	I am confident that I can maintain the working length throughout instrumentation.
Irrigation	I am confident that I can apply irrigation solutions effectively.
Predicting complications	I am confident that I can anticipate possible endodontic complications.
Management of complications	I am confident that I can manage potential endodontic complications.
Obturation	I am confident that I can perform the obturation of root canals successfully.
Post-endodontic restoration	I am confident that I can decide on appropriate post-endodontic restorations.

The adapted scale was originally developed in Turkish. To ensure linguistic equivalence, a forward–backward translation procedure was applied to produce the English version: two bilingual academics independently translated the instrument into English, and a third independent translator produced the back-translation; discrepancies were resolved by expert consensus.

A pilot study was conducted with 10 dental students (5 in the fourth year and 5 in the fifth year) from the Faculty of Dentistry, Ankara University, who were not included in the main sample. Item clarity and comprehensibility were evaluated, and minor wording revisions were made based on participant feedback.

The survey was distributed online via Google Forms (Google LLC, Mountain View, CA, USA) during the second semester of the 2023-2024 academic year (April-May 2024) to fourth- and fifth-year dental students who had completed their endodontic clinical practice. Data were collected from eight dental faculties in Ankara using a single-group survey design. Faculty affiliation was recorded for descriptive purposes only and was not employed as an analytical variable.

Statistical Analysis

The data were collected electronically and subsequently transferred to Microsoft Excel (Microsoft Corp., Redmond, WA, USA) and IBM SPSS Statistics (version 21; IBM Corp., Armonk, NY, USA) for analysis. The level of statistical significance (α) was set at 0.05. The internal consistency of the questionnaire was assessed using Cronbach's alpha coefficient. Descriptive statistics were presented as frequencies and percentages. Given the ordinal structure of the Likert-scale data, differences between fourth- and fifth-year students were analyzed using the linear-by-linear Chi-squared test in 5 x 2 contingency tables.

RESULTS

A total of 135 dental students participated in the survey; of these, 91 (67.4%) were female and 44 (32.6%) were male. Among the participants, 48 (35.6%) were fourth-year students, and 87 (64.4%) were in their fifth year. The participants were enrolled at the following dental faculties: Ankara University (29.6%, n = 40), Gazi University (26.7%, n = 36), Hacettepe University (23.7%, n = 32), Başkent

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University (6.7%, n = 9), Ankara Yıldırım Beyazıt University (5.2%, n = 7), Lokman Hekim University (3.7%, n = 5), Ankara Medipol University (2.2%, n = 3), and the University of Health Sciences (2.2%, n = 3). The self-efficacy of students in relation to endodontic procedures is presented by gender and academic year in Figures 1 and 2, respectively. The questionnaire demonstrated good internal consistency, with a Cronbach's alpha value of 0.874.

According to the results of the linear-by-linear

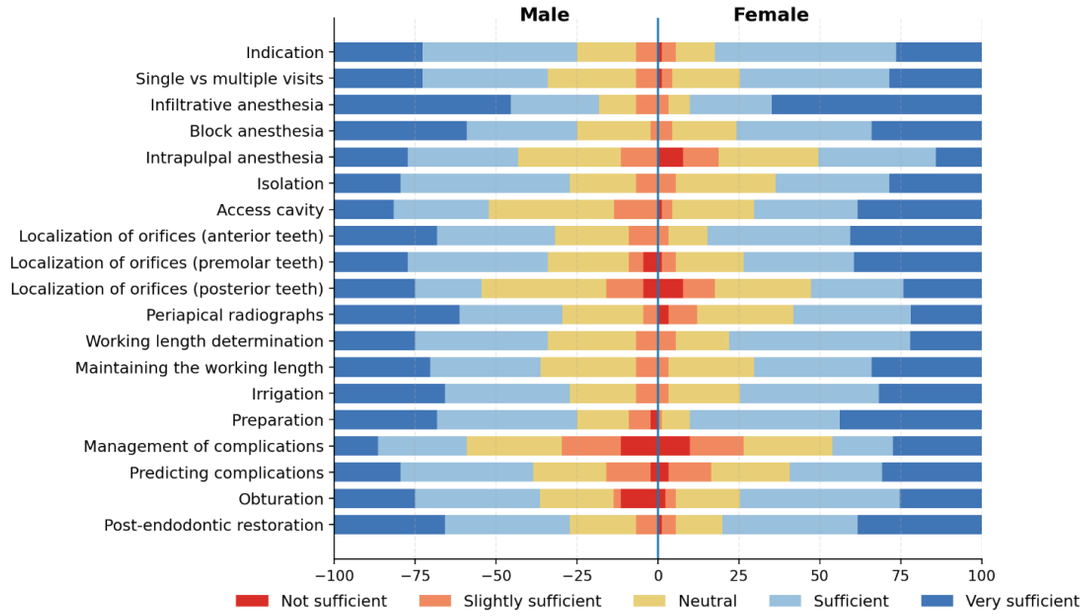


Figure 1. Diverging stacked bar chart showing the percentage (%) distribution of students' self-efficacy levels in endodontic treatment procedures according to gender. Self-efficacy responses are shown according to a five-point Likert scale ranging from "Not sufficient" to "Very sufficient".

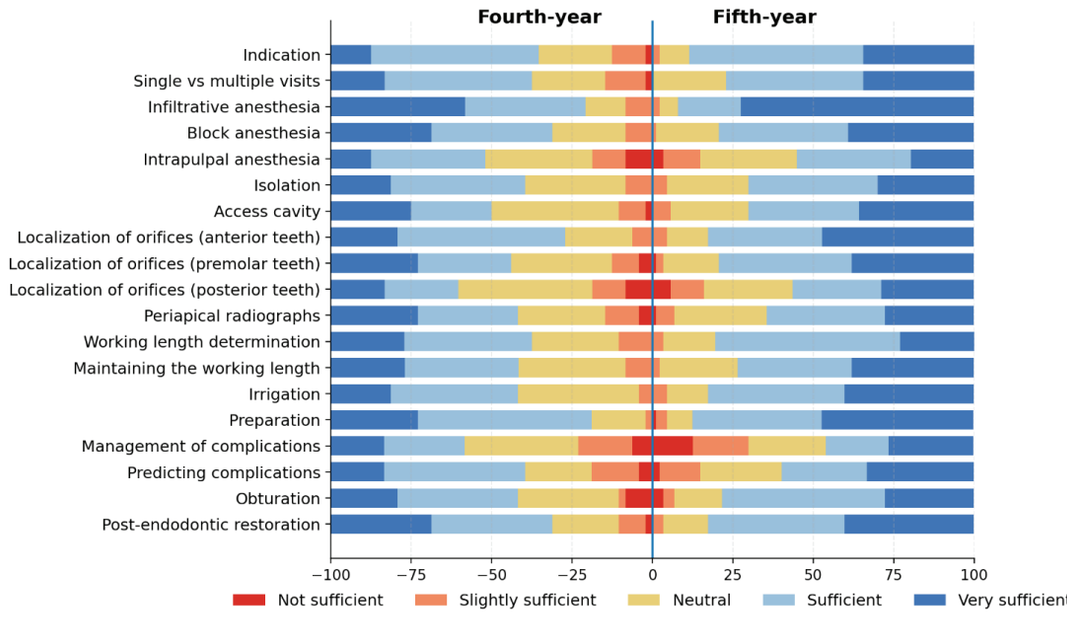


Figure 2. Diverging stacked bar chart showing the percentage distribution (%) of students' self- efficacy levels in endodontic treatment procedures according to academic year. Self-efficacy responses are shown according to a five-point Likert scale ranging from "Not sufficient" to "Very sufficient".

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Table 2. The percentage (%) distribution of students' self-efficacy levels in endodontic treatment procedures according to academic year

Endodontic Procedures		Academic Year						p
		Fourth year n = 48		Fifth year n = 87		Total n = 135		
		n	%	n	%	n	%	
Indication	Not sufficient	1	2.1	0	0.0	1	0.7	0.0001*
	Slightly sufficient	5	10.4	2	2.3	7	5.2	
	Neutral	11	22.9	8	9.2	19	14.1	
	Sufficient	25	52.1	47	54.0	72	53.3	
	Very sufficient	6	12.5	30	34.5	36	26.7	
Single vs multiple visits	Not sufficient	1	2.1	0	0.0	1	0.7	0.002*
	Slightly sufficient	6	12.5	0	0.0	6	4.4	
	Neutral	11	22.9	20	23.0	31	23.0	
	Sufficient	22	45.8	37	42.5	59	43.7	
	Very sufficient	8	16.7	30	34.5	38	28.1	
Infiltrative anesthesia	Not sufficient	0	0.0	0	0.0	0	0.0	0.001*
	Slightly sufficient	4	8.3	2	2.3	6	4.4	
	Neutral	6	12.5	5	5.7	11	8.1	
	Sufficient	18	37.5	17	19.5	35	25.9	
	Very sufficient	20	41.7	63	72.4	83	61.5	
Block anesthesia	Not sufficient	0	0.0	0	0.0	0	0.0	0.113
	Slightly sufficient	4	8.3	1	1.1	5	3.7	
	Neutral	11	22.9	17	19.5	28	20.7	
	Sufficient	18	37.5	35	40.2	53	39.3	
	Very sufficient	15	31.3	34	39.1	49	36.3	
Intrapulpal anesthesia	Not sufficient	4	8.3	3	3.4	7	5.2	0.229
	Slightly sufficient	5	10.4	10	11.5	15	11.1	
	Neutral	16	33.3	26	29.9	42	31.1	
	Sufficient	17	35.4	31	35.6	48	35.6	
	Very sufficient	6	12.5	17	19.5	23	17.0	
Isolation	Not sufficient	0	0.0	0	0.0	0	0.0	0.117
	Slightly sufficient	4	8.3	4	4.6	8	5.9	
	Neutral	15	31.3	22	25.3	37	27.4	
	Sufficient	20	41.7	35	40.2	55	40.7	
	Very sufficient	9	18.8	26	29.9	35	25.9	
Access cavity	Not sufficient	1	2.1	0	0.0	1	0.7	0.033*
	Slightly sufficient	4	8.3	5	5.7	9	6.7	
	Neutral	19	39.6	21	24.1	40	29.6	
	Sufficient	12	25.0	30	34.5	42	31.1	
	Very sufficient	12	25.0	31	35.6	43	31.9	
Localization of orifices (anterior teeth)	Not sufficient	0	0.0	0	0.0	0	0.0	0.017*
	Slightly sufficient	3	6.3	4	4.6	7	5.2	
	Neutral	10	20.8	11	12.6	21	15.6	
	Sufficient	25	52.1	31	35.6	56	41.5	
	Very sufficient	10	20.8	41	47.1	51	37.8	
Localization of orifices (premolar teeth)	Not sufficient	2	4.2	1	1.1	3	2.2	0.011*
	Slightly sufficient	4	8.3	2	2.3	6	4.4	
	Neutral	15	31.3	15	17.2	30	22.2	
	Sufficient	14	29.2	36	41.4	50	37.0	
	Very sufficient	13	27.1	33	37.9	46	34.1	
Localization of orifices (posterior teeth)	Not sufficient	4	8.3	5	5.7	9	6.7	0.106
	Slightly sufficient	5	10.4	9	10.3	14	10.4	
	Neutral	20	41.7	24	27.6	44	32.6	
	Sufficient	11	22.9	24	27.6	35	25.9	
	Very sufficient	8	16.7	25	28.7	33	24.4	

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Periapical radiographs	Not sufficient	2	4.2	1	1.1	3	2.2	0.376
	Slightly sufficient	5	10.4	5	5.7	10	7.4	
	Neutral	13	27.1	25	28.7	38	28.1	
	Sufficient	15	31.3	32	36.8	47	34.8	
	Very sufficient	13	27.1	24	27.6	37	27.4	
Working length determination	Not sufficient	0	0.0	0	0.0	0	0.0	0.088
	Slightly sufficient	5	10.4	3	3.4	8	5.9	
	Neutral	13	27.1	14	16.1	27	20.0	
	Sufficient	19	39.6	50	57.5	69	51.1	
	Very sufficient	11	22.9	20	23.0	31	23.0	
Maintaining the working length	Not sufficient	0	0.0	0	0.0	0	0.0	0.025*
	Slightly sufficient	4	8.3	2	2.3	6	4.4	
	Neutral	16	33.3	21	24.1	37	27.4	
	Sufficient	17	35.4	31	35.6	48	35.6	
	Very sufficient	11	22.9	33	37.9	44	32.6	
Irrigation	Not sufficient	0	0.0	0	0.0	0	0.0	0.002*
	Slightly sufficient	2	4.2	4	4.6	6	4.4	
	Neutral	18	37.5	11	12.6	29	21.5	
	Sufficient	19	39.6	37	42.5	56	41.5	
	Very sufficient	9	18.8	35	40.2	44	32.6	
Preparation	Not sufficient	0	0.0	1	1.1	1	0.7	0.146
	Slightly sufficient	1	2.1	3	3.4	4	3.0	
	Neutral	8	16.7	7	8.0	15	11.1	
	Sufficient	26	54.2	35	40.2	61	45.2	
	Very sufficient	13	27.1	41	47.1	54	40.0	
Management of complications	Not sufficient	3	6.3	11	12.6	14	10.4	0.975
	Slightly sufficient	8	16.7	15	17.2	23	17.0	
	Neutral	17	35.4	21	24.1	38	28.1	
	Sufficient	12	25.0	17	19.5	29	21.5	
	Very sufficient	8	16.7	23	26.4	31	23.0	
Predicting complications	Not sufficient	2	4.2	2	2.3	4	3.0	0.274
	Slightly sufficient	7	14.6	11	12.6	18	13.3	
	Neutral	10	20.8	22	25.3	32	23.7	
	Sufficient	21	43.8	23	26.4	44	32.6	
	Very sufficient	8	16.7	29	33.3	37	27.4	
Obturation	Not sufficient	4	8.3	3	3.4	7	5.2	0.065
	Slightly sufficient	1	2.1	3	3.4	4	3.0	
	Neutral	15	31.3	13	14.9	28	20.7	
	Sufficient	18	37.5	44	50.6	62	45.9	
	Very sufficient	10	20.8	24	27.6	34	25.2	
Post-endodontic restoration	Not sufficient	1	2.1	0	0.0	1	0.7	0.057
	Slightly sufficient	4	8.3	3	3.4	7	5.2	
	Neutral	10	20.8	12	13.8	22	16.3	
	Sufficient	18	37.5	37	42.5	55	40.7	
	Very sufficient	15	31.3	35	40.2	50	37.0	

Data were analyzed with linear-by-linear Chi-squared test in 5 x 2 tables. *p < 0.05 was considered statistically significant.

Chi-squared association test, a statistically significant and positive linear trend was identified in self-efficacy levels as the academic year increased from the fourth to the fifth year for certain endodontic procedures. For indication, single visit versus multiple visits, infiltrative anesthesia, access cavity, localization of canal orifices in anterior and premolar teeth, irrigation, and working length maintenance, higher self-efficacy levels (4–5) were more frequently reported as the academic year increased, while lower levels became less frequent ($p < 0.05$; Table 2). For these procedures, responses demonstrated a systematic shift from low and moderate levels towards higher levels.

In contrast, no statistically significant linear trend

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Table 3. The percentage distribution (%) of students' self- efficacy levels in endodontic treatment procedures according to gender

Endodontic Procedures		Gender						p
		Female n = 91		Male n = 44		Total n = 135		
		n	%	n	%	n	%	
Indication	Not sufficient	1	1.1	0	0.0	1	0.7	0.741
	Slightly sufficient	4	4.4	3	6.8	7	5.2	
	Neutral	11	12.1	8	18.2	19	14.1	
	Sufficient	51	56.0	21	47.7	72	53.3	
	Very sufficient	24	26.4	12	27.3	36	26.7	
Single vs multiple visits	Not sufficient	1	1.1	0	0.0	1	0.7	0.525
	Slightly sufficient	3	3.3	3	6.8	6	4.4	
	Neutral	19	20.9	12	27.3	31	23.0	
	Sufficient	42	46.2	17	38.6	59	43.7	
	Very sufficient	26	28.6	12	27.3	38	28.1	
Infiltrative anesthesia	Not sufficient	0	0.0	0	0.0	0	0.0	0.153
	Slightly sufficient	3	3.3	3	6.8	6	4.4	
	Neutral	6	6.6	5	11.4	11	8.1	
	Sufficient	23	25.3	12	27.3	35	25.9	
	Very sufficient	59	64.8	24	54.5	83	61.5	
Block anesthesia	Not sufficient	0	0.0	0	0.0	0	0.0	0.669
	Slightly sufficient	4	4.4	1	2.3	5	3.7	
	Neutral	18	19.8	10	22.7	28	20.7	
	Sufficient	38	41.8	15	34.1	53	39.3	
	Very sufficient	31	34.1	18	40.9	49	36.3	
Intrapulpal anesthesia	Not sufficient	7	7.7	0	0.0	7	5.2	0.143
	Slightly sufficient	10	11.0	5	11.4	15	11.1	
	Neutral	28	30.8	14	31.8	42	31.1	
	Sufficient	33	36.3	15	34.1	48	35.6	
	Very sufficient	13	14.3	10	22.7	23	17.0	
Isolation	Not sufficient	0	0.0	0	0.0	0	0.0	0.248
	Slightly sufficient	5	5.5	3	6.8	8	5.9	
	Neutral	28	30.8	9	20.5	37	27.4	
	Sufficient	32	35.2	23	52.3	55	40.7	
	Very sufficient	26	28.6	9	20.5	35	25.9	
Access cavity	Not sufficient	1	1.1	0	0.0	1	0.7	0.004*
	Slightly sufficient	3	3.3	6	13.6	9	6.7	
	Neutral	23	25.3	17	38.6	40	29.6	
	Sufficient	29	31.9	13	29.5	42	31.1	
	Very sufficient	35	38.5	8	18.2	43	31.9	
Localization of orifices (anterior teeth)	Not sufficient	0	0.0	0	0.0	0	0.0	0.052
	Slightly sufficient	3	3.3	4	9.1	7	5.2	
	Neutral	11	12.1	10	22.7	21	15.6	
	Sufficient	40	44.0	16	36.4	56	41.5	
	Very sufficient	37	40.7	14	31.8	51	37.8	
Localization of orifices (premolar teeth)	Not sufficient	1	1.1	2	4.5	3	2.2	0.099
	Slightly sufficient	4	4.4	2	4.5	6	4.4	
	Neutral	19	20.9	11	25.0	30	22.2	
	Sufficient	31	34.1	19	43.2	50	37.0	
	Very sufficient	36	39.6	10	22.7	46	34.1	
Localization of orifices (posterior teeth)	Not sufficient	7	7.7	2	4.5	9	6.7	0.939
	Slightly sufficient	9	9.9	5	11.4	14	10.4	
	Neutral	27	29.7	17	38.6	44	32.6	
	Sufficient	26	28.6	9	20.5	35	25.9	
	Very sufficient	22	24.2	11	25.0	33	24.4	

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Periapical radiographs	Not sufficient	3	3.3	0	0.0	3	2.2	0.036*
	Slightly sufficient	8	8.8	2	4.5	10	7.4	
	Neutral	27	29.7	11	25.0	38	28.1	
	Sufficient	33	36.3	14	31.8	47	34.8	
	Very sufficient	20	22.0	17	38.6	37	27.4	
Working length determination	Not sufficient	0	0.0	0	0.0	0	0.0	0.353
	Slightly sufficient	5	5.5	3	6.8	8	5.9	
	Neutral	15	16.5	12	27.3	27	20.0	
	Sufficient	51	56.0	18	40.9	69	51.1	
	Very sufficient	20	22.0	11	25.0	31	23.0	
Maintaining the working length	Not sufficient	0	0.0	0	0.0	0	0.0	0.399
	Slightly sufficient	3	3.3	3	6.8	6	4.4	
	Neutral	24	26.4	13	29.5	37	27.4	
	Sufficient	33	36.3	15	34.1	48	35.6	
	Very sufficient	31	34.1	13	29.5	44	32.6	
Irrigation	Not sufficient	0	0.0	0	0.0	0	0.0	0.914
	Slightly sufficient	3	3.3	3	6.8	6	4.4	
	Neutral	20	22.0	9	20.5	29	21.5	
	Sufficient	39	42.9	17	38.6	56	41.5	
	Very sufficient	29	31.9	15	34.1	44	32.6	
Preparation	Not sufficient	0	0.0	1	2.3	1	0.7	0.013*
	Slightly sufficient	1	1.1	3	6.8	4	3.0	
	Neutral	8	8.8	7	15.9	15	11.1	
	Sufficient	42	46.2	19	43.2	61	45.2	
	Very sufficient	40	44.0	14	31.8	54	40.0	
Management of complications	Not sufficient	9	9.9	5	11.4	14	10.4	0.456
	Slightly sufficient	15	16.5	8	18.2	23	17.0	
	Neutral	25	27.5	13	29.5	38	28.1	
	Sufficient	17	18.7	12	27.3	29	21.5	
	Very sufficient	25	27.5	6	13.6	31	23.0	
Predicting complications	Not sufficient	3	3.3	1	2.3	4	3.0	0.741
	Slightly sufficient	12	13.2	6	13.6	18	13.3	
	Neutral	22	24.2	10	22.7	32	23.7	
	Sufficient	26	28.6	18	40.9	44	32.6	
	Very sufficient	28	30.8	9	20.5	37	27.4	
Obturation	Not sufficient	2	2.2	5	11.4	7	5.2	0.128
	Slightly sufficient	3	3.3	1	2.3	4	3.0	
	Neutral	18	19.8	10	22.7	28	20.7	
	Sufficient	45	49.5	17	38.6	62	45.9	
	Very sufficient	23	25.3	11	25.0	34	25.2	
Post-endodontic restoration	Not sufficient	1	1.1	0	0.0	1	0.7	0.476
	Slightly sufficient	4	4.4	3	6.8	7	5.2	
	Neutral	13	14.3	9	20.5	22	16.3	
	Sufficient	38	41.8	17	38.6	55	40.7	
	Very sufficient	35	38.5	15	34.1	50	37.0	

Data were analyzed with linear-by-linear Chi-squared test in 5 x 2 tables. *p < 0.05 was considered statistically significant.

was identified between academic year and self-efficacy levels for block and intrapulpal anesthesia, isolation, working length determination, preparation, management of complications, predicting complication, obturation, post-endodontic restoration, periapical radiography steps (p > 0.05; Table 2). Although a tendency towards higher levels was observed among fifth-year students in these areas, this change did not reach statistical significance according to the linear trend test. A significant linear trend was observed between gender and self-efficacy levels, with higher self-efficacy reported by female students for access cavity and preparation and by male students for periapical radiography procedures (p < 0.05; Table 3).

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DISCUSSION

Undergraduate dental education is expected to prepare graduates who can deliver safe and high-quality patient care, demonstrate awareness of their professional boundaries, and refer cases beyond their competence according to the 2024 European Society of Endodontology (ESE) Undergraduate Curriculum Guidelines.[14] Dental schools should address the challenges students face early in their education to help them manage the complex aspects of endodontic treatment more effectively. Ongoing curriculum review, supported by student feedback, facilitates the recognition of weaknesses and the adoption of appropriate revisions to improve the overall standard of teaching.[5] Globally, dental schools are reforming their curricula by incorporating evidence-based, patient-focused comprehensive care models while encouraging the use of integrated learning approaches.[23]

Students' competencies should be assessed regularly through structured evaluations to ensure readiness for independent clinical practice.[14] Recently, contrary to the traditional approach, student performance in endodontics has been evaluated not only on theoretical knowledge and technical skills but also on clinical decision-making and self-perceived competence.[2] These outcomes are best supported by learning environments that foster critical thinking and the integration of knowledge, thereby enhancing students' clinical problem-solving abilities.[3] Nonetheless, limited infrastructure, demanding curricula, and insufficiently qualified staff may impede the development of students' clinical competence and procedural readiness in dental practice.[24]

Developing self-efficacy is a central aspect of dental education. The quality and scope of undergraduate training directly influence students' belief in their ability to perform endodontic procedures independently.[16] Students with higher self-efficacy transfer their knowledge and skills to endodontic practice with greater effectiveness and clinical competence, demonstrating enhanced procedural performance.[25] Self-assessment of competence provides a valuable means of evaluating how well the curriculum meets students' learning needs and of identifying the impact of specific educational components.[19]

Surveys are one of the main methods used to collect data on the challenges faced by students.[8, 9] The present survey was conducted to assess students' perceived self-efficacy across various endodontic procedures, showing good internal consistency and supporting its use for evaluating self-efficacy in undergraduate dental students.

In Türkiye, dental education follows the Turkish Higher Education Qualifications Framework, which guides all faculties in designing their curricula and defining learning outcomes in line with national standards. Accordingly, the endodontic clinical training across the eight participating faculties was comparable in terms of its basic structure and progression. In Turkish dental schools, the first three to four years focus on theoretical and preclinical training. This is followed by supervised clinical practice, where knowledge is applied to patient care, integrating theory with hands-on experience. Each student completes a set number of procedures specified in the curriculum for their academic year. While fourth-year students carry out basic endodontic treatments, fifth-year students treat a greater number of patients, thereby advancing their clinical experience. Consequently, the institutional distribution of participants reflected the level of clinical exposure defined by academic year and structured in a comparable manner across faculties. Such reflective practices not only provide valuable feedback for educators but also help students develop a greater awareness of their own learning progress, further reinforcing the link between self-efficacy and clinical competence.

In the present study, students' self-assessments mostly fell within the sufficient range. According to Bandura,[13] a sufficient level of competence is essential for developing self-efficacy. This may indirectly indicate that students have reached a certain level of clinical competence. However, as these findings rely on self-reported data, they should be interpreted cautiously, given that they may not accurately reflect students' actual clinical performance.

In the present study, a statistically significant difference was found in self-efficacy levels during various stages of root canal treatment according to academic year and gender; therefore, the null hypothesis was rejected. Female students reported higher self-efficacy than males in access cavity and preparation.

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In contrast, male students reported higher self-efficacy in periapical radiography. Some previous studies claimed that female students often show higher academic responsibility and achievement, which may increase their confidence in certain clinical skills.[26, 27] Soto-Araya *et al*.[1] found that female students demonstrated higher abilities in organization, planning, and decision-making compared to their male colleagues. However, the absence of gender-related differences across the majority of the assessed procedures indicates that such differences were limited to a small number of specific skills rather than representing a generalized pattern within endodontic clinical practice.

In this study, fifth-year students reported significantly higher self-efficacy than fourth-year students in some endodontic procedures, whereas self-efficacy levels remained similar for a substantial proportion of them. This finding indicates that self-efficacy during clinical training does not increase at the same rate or in a linear manner across all stages of endodontic treatment. In other words, although increased clinical experience strengthens students' confidence in certain procedures, this effect cannot be assumed to extend equally or consistently to every procedural step. Some endodontic procedures may allow learning, and consequently self-efficacy, to reach a certain level over a shorter period of time, whereas others may require higher levels of cognitive and technical competence. This suggests that more prolonged and targeted clinical experience may be needed for learning to be consolidated. Overall, self-efficacy perceptions related to the various steps of endodontic treatment are shaped not only by academic level, but also by multidimensional factors such as the frequency of endodontic clinical exposure, technical complexity, and learning requirements of the procedure. Nevertheless, the shift towards higher self-efficacy levels in favor of fifth year students observed in a limited number of procedures suggests that greater final year clinical exposure may contribute to increased confidence, in line with previous evidence on the role of hands-on clinical experience in enhancing self-efficacy and clinical competence.[16] These findings carry direct implications for endodontic curriculum design. Procedural areas in which self-efficacy did not significantly increase between the fourth and fifth year, notably complication management, obturation, and block anesthesia, may represent domains where current training provisions are insufficient to consolidate students' competence beliefs. Targeted educational interventions such as simulation-based training, case-based learning, and structured clinical feedback may be particularly warranted in these areas. Moreover, the procedure-specific nature of self-efficacy gains supports a competency-based approach to curriculum mapping, whereby instructional resources and clinical case requirements are allocated in proportion to the complexity and learning demands of individual procedural steps. The 2024 ESE Undergraduate Curriculum Guidelines[14] provide a valuable framework against which endodontic training standards can be benchmarked and revised in light of such evidence.

Several limitations of the present study should be acknowledged. First, all data are self-reported; students' perceptions of their own procedural competence may not accurately reflect their objective clinical performance. Self-efficacy judgments are subjective appraisals of capability that do not always correspond to demonstrated skill.[13] Social desirability bias whereby students may overestimate their competence in a survey context cannot be excluded. Future studies should examine the correspondence between self-efficacy perceptions and objective competency indicators such as faculty assessments, structured clinical evaluations, or objective structured clinical examinations (OSCEs).

Second, the cross-sectional design precludes causal inference. Although fifth-year students reported higher self-efficacy than fourth-year students across certain procedures, this difference cannot be attributed to within-individual development over time, as the two groups were not followed longitudinally. The observed pattern may reflect cohort effects, differences in prior clinical exposure, or other unmeasured curricular variables. Longitudinal studies tracking the same cohort across academic years are needed to establish genuine developmental trajectories of endodontic self-efficacy.

Third, although data were gathered from eight dental faculties in Ankara, the study followed a single-group survey design and faculty was not employed as an analytical variable. Given the unequal and in some cases limited sample sizes per institution, inter-fac-

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ulty statistical comparisons were not conducted, as such analyses would have been insufficiently powered to yield reliable conclusions. The multi-center sampling approach was intended to increase the representativeness of the findings across the Ankara dental education context rather than to enable institutional comparisons. Nonetheless, institutional differences in curriculum structure, clinical case volume requirements, simulation training resources, and instructional approaches may have introduced heterogeneity in students' self-efficacy levels that the present design cannot fully disaggregate. Future studies employing faculty-stratified sampling with adequate statistical power per institution would enable a more refined examination of how institutional factors moderate the development of endodontic self-efficacy throughout undergraduate training.

Fourth, the study was conducted exclusively among dental students at faculties located in Ankara, which limits the generalizability of the findings to other regions of Türkiye and to dental education systems in other countries. Replication across diverse institutional and national contexts is encouraged. Future studies should compare students' self-efficacy levels with their actual clinical performance based on standardized assessment criteria to better understand the relationship between perceived and demonstrated competence in endodontic procedures.

CONCLUSION

Within the limitations of this study, advancing academic level was associated with higher self-efficacy perceptions for specific endodontic procedures, such as indication, infiltrative anesthesia, access cavity preparation, canal orifice localization, and irrigation. While this finding suggests a gradual development of professional confidence throughout the educational process, it also demonstrates that such progression does not occur uniformly across all endodontic procedures. Moreover, gender-related differences in self-efficacy are limited to a very small number of endodontic procedures. Overall, the majority of students reported moderate to high levels of self-efficacy in relation to endodontic practice.

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CONFLICT OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

DATA AVAILABILITY STATEMENT

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

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Institutional Ethics Committee of Ankara University. All procedures were conducted in accordance with the ethical standards outlined in the Declaration of Helsinki by the World Medical Association (WMA). Every participant provided their informed consent prior to participation in the study.

CONSENT FOR PUBLICATION

Not applicable.

REFERENCES

1. Soto-Araya M, Baños JE, Pérez J, Moyano E. Generic Competencies in Dentistry: Students' and Teachers' Perceptions of Their Professional Relevance and Their Development in Undergraduate Studies at Universidad Diego Portales of Chile. Eur J Dent Educ 2025;29:304-14.

2. Longridge NN, Dutta A, Fox K. Endodontic education - present status and future directions. Br Dent J 2025;238:567-72.

3. Friedlander L, Hunt G, Chandler N, Daniel B. Students' experience and perceptions of undergraduate endodontic education in New Zealand. Aust Endod J 2023;49:492-502.

4. Baaij A, Özok AR. Influence of Method of Teaching Endodontics on the Self-Efficacy and Self-Perceived Competence of Undergraduate Dental Students. Eur Endod J 2018;3:31-7.

5. Altorisy A, Ahmad MZ. Assessing confidence levels in endodontic procedures among senior undergraduate dental students at Qassim university, Saudi Arabia: A Cross-Sectional observational study. Cureus 2023;15:e43649.

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6. Nafea ET. Does Self-Efficacy Affect Clinical Reasoning in Dental Students? Int Dent J 2022;72:872-8.

7. Ilgüy D, Ilgüy M, Fisekçioglu E, Ersan N, Tanalp J, Dölekoglu S. Assessment of root canal treatment outcomes performed by Turkish dental students: results after two years. J Dent Educ 2013;77:502-9.

8. Almutairi M, Alattas MH, Alamoudi A, Bahammam SA, Zidane B, Almutairi N, *et al.* Challenges Assessment in Endodontics Among Undergraduate Students. Cureus 2023;15:e43215.

9. Martins RC, Seijo MO, Ferreira EF, Paiva SM, Ribeiro Sobrinho AP. Dental students' perceptions about the endodontic treatments performed using NiTi rotary instruments and hand stainless steel files. Braz Dent J 2012;23:729-36.

10. Deeb JG, Carrico CK, Laskin DM, Koertge TE. Influence of Self-Assessment on Dental Students' Performance on Technical Assessments in Periodontics. J Dent Educ 2019;83:457-63.

11. Fong W, Heidarifar O, Killough S, Lappin MJ, El Karim IA. An audit on technical quality of root fillings performed by undergraduate students. Int Endod J 2018;51:e197-e203.

12. Zimmerman BJ. Self-Efficacy: An Essential Motive to Learn. Contemp Educ Psychol 2000;25:82-91.

13. Bandura A. Self-efficacy: toward a unifying theory of behavioral change. Psychol Rev 1977;84:191-215.

14. Baaij A, Kruse C, Whitworth J, Jarad F. European Society of Endodontology Undergraduate Curriculum Guidelines for Endodontology. Int Endod J 2024;57:982-95.

15. Murray CM, Chandler NP. Undergraduate endodontic teaching in New Zealand: students' experience, perceptions and self-confidence levels. Aust Endod J 2014;40:116-22.

16. Davey J, Bryant ST, Dummer PM. The confidence of undergraduate dental students when performing root canal treatment and their perception of the quality of endodontic education. Eur J Dent Educ 2015;19:229-34.

17. Ali Al-Kadhim AH, Nor Azan A, Muhammad Salim M, Yousif Al-Ani ST, Jaafar A. Evaluation on the perception of final year dental students on their confidence level regarding endodontic treatments: a cross sectional analysis. IIUM Journal of Orofacial and Health Sciences 2022;3:102-10.

18. Javed MQ, Bhatti UA. Students' performance in clinics and self-perceived Confidence in performing Endodontic procedures: A correlation study. Pak J Med Sci 2023;39:203-8.

19. Tanalp J, Güven EP, Oktay I. Evaluation of dental students′ perception and self-confidence levels regarding endodontic treatment. Eur J Dent 2013;7:218-24.

20. Tavares LG, Lima SMF, Lima MG, Arruda MP, Menegazzi TC, Rezende TMB. Undergraduate dentistry students' perception of difficulties regarding endodontic treatment. Aust Endod J 2019;45:98-105.

21. Baaij A, Özok AR, Væth M, Musaeus P, Kirkevang LL. Self-efficacy of undergraduate dental students in Endodontics within Aarhus and Amsterdam. Int Endod J 2020;53:276-84.

22. Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. Hillsdale (NJ): Lawrence Erlbaum Associates; 1988.

23. Praveen G, Pujitha D, Lakshmi Durga IS, Uddaraju SR, Narisetty SGP, Sayana RG, *et al.* Comparing traditional and comprehensive clinical training methods in dental education: a study of students' self-confidence and clinical performance. Br Dent J 2023;234:682-6.

24. Lynch CD, Ash PJ, Chadwick BL. Student perspectives and opinions on their experience at an undergraduate outreach dental teaching centre at Cardiff: a 5-year study. Eur J Dent Educ 2010;14:12-6.

25. Baaij A, Özok AR. Method of teaching undergraduate students to perform root canal treatment: It's influence on the quality of root fillings. Eur J Dent Educ 2018;22:e221-e7.

26. Kærsgaard JLB, Christensen MK, Søndergaard PY, Naukkarinen J. Gender differences in dentistry: A qualitative study on students' intrinsic and extrinsic motivations for entering dentistry at higher education. Eur J Dent Educ 2021;25:495-505.

27. Kukulu K, Korukcu O, Ozdemir Y, Bezci A, Calik C. Self-confidence, gender and academic achievement of undergraduate nursing students. J Psychiatr Ment Health Nurs 2013;20:330-5.

Diş Hekimliği Öğrencilerinin Kök Kanal Tedavisi Performansına İlişkin Öz Yeterliklerinin Değerlendirilmesi: Bir Anket Çalışması

ÖZET

Amaç: Diş hekimliği öğrencilerinin öz yeterlik düzeylerinin değerlendirilmesi, eğitimcilerin müfredatta hangi alanların etkili olduğunu ve hangi alanlarda ek desteğe ihtiyaç duyulduğunu daha iyi anlamalarına yardımcı olabilir. Bu çalışma, lisans düzeyindeki diş hekimliği öğrencilerinin kök kanal tedavisi uygulama konusundaki öz yeterliklerindeki farklılıkları akademik yıl ve cinsiyete göre araştırmayı amaçlamıştır.

Gereç ve Yöntemler: Çalışma Ankara, Türkiye'deki sekiz diş hekimliği fakültesinin, endodonti klinik uygulamalarını tamamlamış olan dördüncü ve beşinci sınıf öğrencileri arasında yürütüldü. Anket, demografik sorulardan ve öğrencilerin kök kanal tedavisinin farklı aşamalarını uygulamadaki öz yeterliklerini değerlendiren maddelerden oluşmaktaydı. Yanıtlar, 5'li Likert ölçeğinde derecelendirildi (1 = yetersiz, 5 = çok yeterli). Anketin iç tutarlılığı Cronbach alfa katsayısıyla değerlendirildi; akademikyıl ile cinsiyet arasında sıralı Likert ölçekli yanıtlardaki eğilimleri değerlendirmek amacıyla doğrusal eğilim ki-kare testi uygulandı. İstatistiksel anlamlılık düzeyi $p < 0.05$ olarak belirlendi.

Bulgular: Çalışmaya 44'ü (%32.6) erkek, 91'i (%67.4) kadın toplam 135 öğrenci katıldı. Katılımcıların 48'i (%35.6) dördüncü

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sınıf, 87'si (%64.4) beşinci sınıf öğrencisiydi. Tanımlayıcı analiz, öğrencilerin öz yeterlik düzeylerinin çoğu endodontik işlemde nötr ile yüksek aralıkta olduğunu gösterdi. Beşinci sınıf öğrencileri; endikasyon, tek seans/çok seans tedavi, infiltratif anestezi, giriş kavitesi, anterior ve premolar dişlerde kanal ağızlarının lokalizasyonu, irrigasyon ve çalışma boyunun korunmasında dördüncü sınıf öğrencilerine kıyasla daha yüksek öz yeterlik bildirdi $p < 0.05$; buna karşılık, kalan işlemler için böyle bir eğilim gözlenmedi ($p > 0.05$). Cinsiyet ile öz yeterlik düzeyleri arasında, giriş kavitesi, preparasyon ve periapikal radyografi dışında ($p < 0.05$) anlamlı bir doğrusal eğilim saptanmadı.

Sonuç: Öğrenciler, endodontik işlemlere ilişkin öz yeterlik algılarını genel olarak orta ile yüksek düzeyde bildirdi; akademik yıl ve cinsiyete bağlı farklılıklar sınırlı sayıdaki endodontik işlemle kısıtlı kaldı.

Anahtar Kelimeler: Anket; Diş hekimliği öğrencileri; Endodonti; Öz yeterlik

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Original Research Article

The Effect of Bioactive Liner Materials on the Bond Strength of Universal Adhesives to Dentin

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ABSTRACT

Aim: This *in vitro* study aims to investigate how different bioactive base materials influence the bond strength of two universal adhesive systems, Single Bond Universal and Prime&Bond Universal, when applied to dentin-liner complexes. Understanding the interaction between adhesives and base materials is critical to improving the longevity of restorations placed in deep cavities.

Materials and Methods: Eighty extracted human molars were sectioned and standardized dentin surfaces were prepared. Four bioactive base materials (TheraCal LC, Riva LC, Riva SC, and BioMTA+) were applied, followed by one of the two universal adhesives. Composite build-ups were placed and specimens underwent 10,000 thermocycles to simulate oral aging. Shear bond strength (SBS) testing was performed, and failure modes were analyzed microscopically. A two-way ANOVA and Tukey's post hoc tests were used ($\alpha = 0.05$).

Results: The type of base material had a statistically significant effect on bond strength ($p < 0.001$), while the adhesive brand did not ($p = 0.25$). TheraCal LC yielded the highest mean bond strength (20.6 ± 2.1 MPa), whereas BioMTA+ showed the lowest (10.2 to 11.4 MPa). A failure mode analysis revealed that cohesive failures predominated in the BioMTA+ group, suggesting internal material weakness.

Conclusion: The bond strength of universal adhesives is substantially affected by the choice of bioactive base material. TheraCal LC demonstrated superior performance, which is likely due to its resin-modified composition and light-curing capability. No significant differences were observed between the two adhesives tested. Clinically, the use of resin-modified calcium silicate materials such as TheraCal LC may enhance adhesive performance and improve the longevity of restorations in deep cavities, whereas additional surface treatment strategies may be required when using materials like BioMTA+.

Keywords: Universal adhesives; Dentin bonding; Bioactive materials; Shear bond strength; Glass ionomer cement

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INTRODUCTION

Dental caries is a biofilm-mediated disease caused by the frequent consumption of fermentable carbohydrates and is among the most prevalent chronic conditions worldwide.[1,2] Current approaches in caries management prioritize minimally invasive techniques, such as selective caries removal, with the goal of preserving pulp vitality and maintaining sound tooth structure.[3,4] In deep carious lesions close to the pulp, the placement of a suitable liner or base material is essential to provide pulpal protection and to enhance the bonding interface for definitive restorations.[5,6]

Various bioactive base materials have been developed to meet these clinical requirements. Calcium silicate-based materials such as TheraCal LC and BioMTA+, as well as conventional and resin-modified glass ionomer cements such as Riva SC and Riva LC, are widely used for their biocompatibility, ion release capacity, and remineralization potential.[7-9] However, the substrate characteristics of these materials, including surface energy, porosity, and hydrophilicity, may significantly influence the bonding effectiveness of adhesives.[10,11]

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Simultaneously, universal adhesives have gained prominence in clinical dentistry due to their applicability in multiple etching modes and their inclusion of functional monomers such as 10-MDP, which can chemically bond to hydroxyapatite.[12,13] Despite their increasing use, limited evidence is available regarding the performance of universal adhesives on bioactive base materials, particularly under conditions that simulate intraoral thermal stress.[14] The strength and durability of the adhesive interface are critical for restoration longevity and clinical success.[15-17]

The purpose of this study was to assess the shear bond strength of two universal adhesive systems, Single Bond Universal and Prime&Bond Universal, when applied to dentin surfaces lined with various bioactive base materials, including TheraCal LC, Riva LC, Riva SC, and BioMTA+. Thermocycling was used to simulate intraoral conditions. The study specifically examined how the type of base material and adhesive system influenced the bonding performance. The null hypothesis proposed that the adhesive system would not significantly affect bond strength, while the type of bioactive base material would have a significant impact.

MATERIALS AND METHODS

An a priori power analysis was performed using G*Power 3.1.9.7 to determine the required sample size for this study. Assuming a large effect size (f = 0.50), a significance level of α = 0.05, and a statistical power of 0.80, the minimum required total sample size was calculated as fifty-two. To ensure adequate power and to account for potential data loss, a total of eighty specimens were used, with ten specimens assigned to each of the eight experimental groups.[18] The study followed ethical approval from the Hacettepe University Ethics Committee (Approval No: 21/212).

Table 1. The Composition and Manufacturer Information of the Adhesives, Base Materials, and Composite Resin Tested

Material Name	Manufacturer	Composition	Lot No.
Single Bond Universal	3M ESPE, St. Paul, Minn., USA	10-MDP, phosphoric acid ester monomer, HEMA, silane, dimethacrylate, Vitrebond copolymer, filler, ethanol, water, initiators pH = 2.7 (ultra mild)	587885
Prime&Bond Universal	Dentsply Sirona, Konstanz, Germany	Phosphoric acid-modified acrylate resin, bifunctional acrylate, multifunctional acrylate, acidic acrylate, isopropanol, water, initiator, stabilizer pH > 2.5	1911000625
TheraCal LC	Bisco Inc, Schaumburg, IL, USA	Light-cured single-component paste. Resin components: bisphenol A-glycidyl methacrylate (BisGMA); polyethylene glycol dimethacrylate (PEGDMA)Modified calcium silicate with CaO; particles (type III Portland cement); strontium glass; silica; barium sulfate ($BaSO_4$); and barium zirconate ($BaZrO_3$)	1900004288
Riva Self Cure	SDI Ltd., Victoria, Australia	Powder: Strontium fluoroaluminosilicate glass, polyacrylic acid copolymer powders, pigments Liquid: Acrylic acid homopolymer, tartaric acid	B1611142F
Riva Light Cure	SDI Ltd., Victoria, Australia	Powder: 95–100 % by weight glass powder Liquid: 20–30 % by weight 2-hydroxyethyl methacrylate, 15–25 % acrylic acid homopolymer, 10-20% dimethacrylate cross-linker, 10–20% acidic monomer, 1–5% tartaric acid	K1803093EG
BioMTA+	PPH Cerkamed, Stalowa Wola, Poland	Powder: Calcium oxide, hydroxyapatite, silicon, iron, aluminum, sodium, potassium, bismuth, magnesium, and zirconium oxides, calcium phosphate Liquid: Distilled water, calcium catalyst	2811221
Filtek Z550 Nano Hybrid Universal Restorative	3M ESPE, St. Paul, Minn., USA	Surface-modified 20 nm zirconia/silica filler (81.8% by weight, 67.8% by volume), Bis-GMA, UDMA, Bis-EMA, PEGDMA, and TEGDMA monomers	N904868

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Specimen Preparation and Grouping

Eighty extracted sound human third molars were cleaned of soft tissue residues and stored in 0.1 % thymol solution. Each tooth was sectioned at the cementoenamel junction using a water-cooled diamond saw. The crowns were embedded in acrylic resin with the buccal dentin surface exposed. Standardized flat dentin surfaces were created using 600-grit silicon carbide paper under running water.

Standardized cylindrical cavities (1 mm in diameter and depth) were prepared on each dentin surface. The teeth were then randomly divided into eight experimental groups (n = 10) according to the combination of base material and adhesive system used:

- G1: TheraCal LC + Single Bond Universal
- G2: Riva LC + Single Bond Universal
- G3: Riva SC + Single Bond Universal
- G4: BioMTA+ + Single Bond Universal
- G5: TheraCal LC + Prime&Bond Universal
- G6: Riva LC + Prime&Bond Universal
- G7: Riva SC + Prime&Bond Universal
- G8: BioMTA+ + Prime&Bond Universal

The composition and manufacturer details of the adhesives, base materials, and composite resin used in this study are presented in Table 1.

Base Material Application

Each cavity was filled with one of the four bioactive materials:

- TheraCal LC (light-cured, resin-modified calcium silicate; Bisco, USA)
- Riva LC and Riva SC (resin-modified and conventional glass ionomer cements; SDI, Australia)
- BioMTA+ (self-setting calcium silicate; Biodinâmica, Brazil)

The TheraCal LC and Riva LC were light-cured for twenty seconds using a high-intensity LED light (≥ 1200 mW/cm²). The Riva SC and BioMTA+ were allowed to self-cure as per the manufacturer's instructions.

Adhesive and Composite Resin Application

Following the base material setting, the surfaces (base + dentin) were etched with 37% phosphoric acid for fifteen seconds, rinsed, and gently air-dried. After this, the assigned universal adhesive system was applied:

- Single Bond Universal (3M ESPE, USA)
- Prime&Bond Universal (Dentsply Sirona, Germany)

A transparent cylindrical mold (2 mm diameter × 2 mm height) was placed on the bonded area and filled with nanohybrid composite (Filtek Z550, 3M ESPE). Each increment was light-cured for twenty seconds.

Thermocycling

All the specimens were stored in distilled water at 37 °C for forty-eight hours before undergoing thermocycling for 10,000 cycles between 5°C and 55°C, with a dwell time of thirty seconds and transfer time of five seconds. This protocol simulated long-term intraoral thermal stress as recommended in the literature.[14]

The Shear Bond Strength Test

The shear bond strength (SBS) was tested using a universal testing machine (Shimadzu AGS-X, Japan) at a crosshead speed of 0.5 mm/min. The maximum load (N) at debonding was recorded and converted to megapascals (MPa) using the formula:

Bond Strength (MPa) = Force (N)/Bonded Area (mm²)

Failure Mode Analysis

Fractured specimens were examined under a stereomicroscope (× 10 magnification) to classify failure modes as:

- Adhesive failure (at interface),
- Cohesive failure (within dentin, base, or composite),
- Mixed failure (combination of adhesive and cohesive).

Statistical Analysis

Data were analyzed using SPSS v24.0 (IBM Corp., USA). A two-way ANOVA was used to evaluate the effect of adhesive system and base material. Tukey's post hoc test was performed for pairwise comparisons. The statistical significance was set at α = 0.05.

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RESULTS

The mean shear bond strength (SBS) values of the tested groups are presented in Table 2. A significant interaction was found between the type of bioactive material and the adhesive system used ($p < 0.05$). Among the tested groups, the TheraCal LC + Single Bond Universal group (G1) showed the highest mean bond strength, followed by TheraCal LC + Prime&Bond Universal (G5), and Riva LC + Single Bond Universal (G2). The interaction of the mean bond strength values between different base materials and adhesive systems is illustrated in Figure 1.

The BioMTA+ groups (G4 and G8) exhibited the lowest bond strength values overall, and both were significantly lower than the other base material groups ($p < 0.05$). There was no statistically significant difference in bond strength between the Single Bond Universal and the Prime&Bond Universal within the same base material group ($p > 0.05$).

The results of the two-way ANOVA indicated that the type of base material had a statistically significant effect on the bond strength ($p < 0.001$), while the type of adhesive system did not ($p = 0.25$). However, a significant interaction was observed between the base material and the adhesive system ($p = 0.036$). A fractographic analysis revealed distinct failure patterns across the groups (Table 3). Adhesive failures were predominantly observed in the TheraCal LC and Riva LC groups, whereas cohesive failures within the base material were more frequently encountered in the BioMTA+ groups. Representative images of these failure modes are presented in Figure 2.

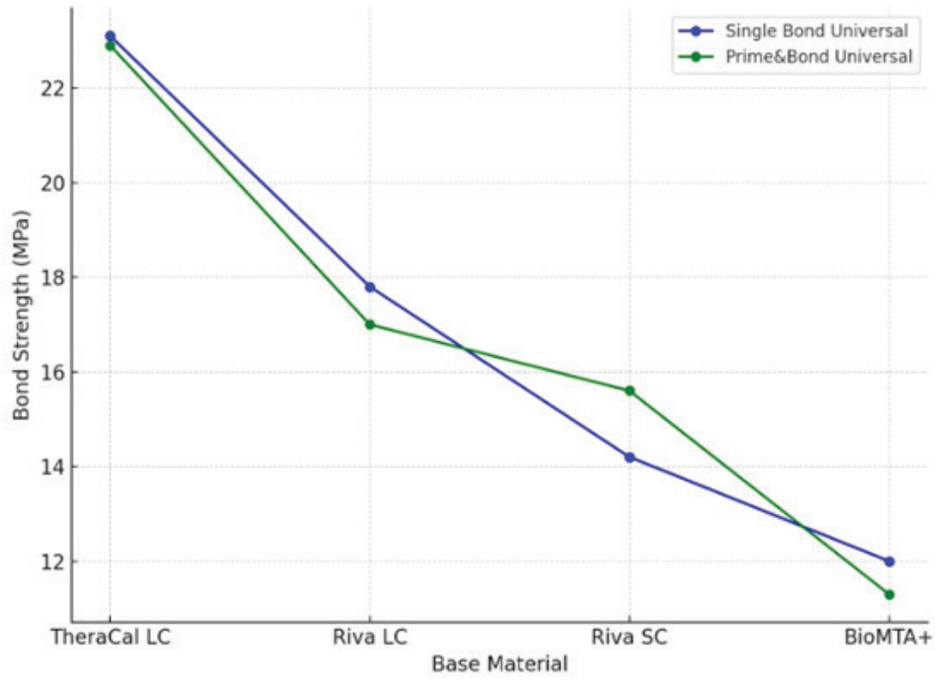


Figure 1. Line graph showing the interaction of the mean bond strength values of the tested universal adhesives with different base materials.

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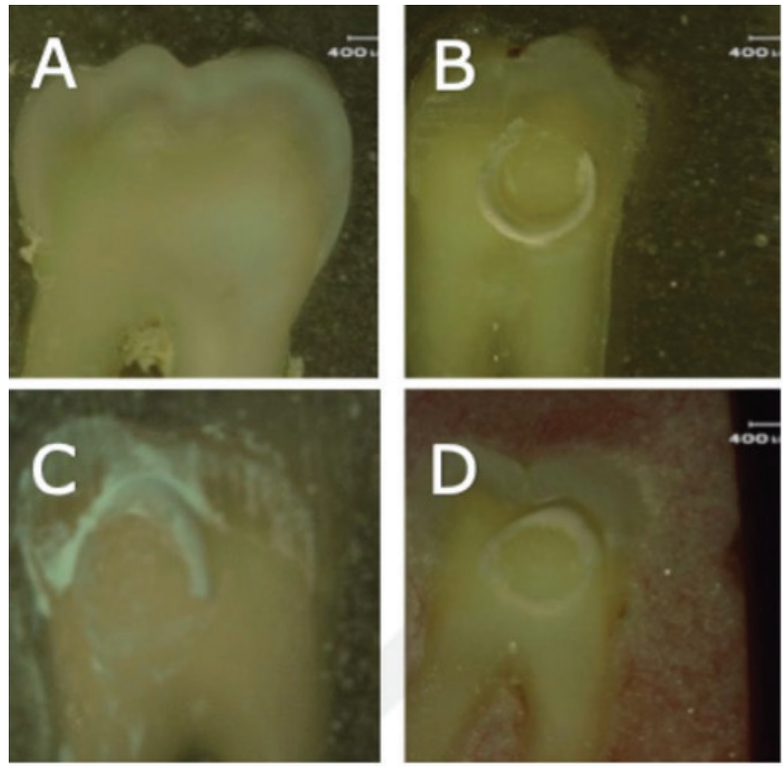


Figure 2. Stereomicroscope images of failure types:
A) Adhesive failure, B-C) Mixed failure, D) Cohesive failure.

Table 2. Shear Bond Strength (MPa)-Mean ± SD

Study Groups	Base Material + Adhesive	Mean ± SD (MPa)
G1	TheraCal LC + SB	20.6 ± 2.1[a]
G2	Riva LC + SB	18.4 ± 1.9[b]
G3	Riva SC + SB	15.9 ± 1.7[c]
G4	BioMTA+ + SB	11.4 ± 1.6[d]
G5	TheraCal LC + PB	19.8 ± 2.3[a]
G6	Riva LC + PB	17.9 ± 2.0[b]
G7	Riva SC + PB	15.4 ± 1.8[c]
G8	BioMTA+ + PB	10.2 ± 1.5[d]

Different superscript letters indicate statistically significant differences among base material groups according to Tukey's post hoc test ($p < 0.05$). (SB: Single Bond Universal; PB: Prime&Bond Universal.)

Table 3. The Failure Mode Distribution by Group

Study Groups	Adhesive (%)	Cohesive (%)	Mixed (%)
G1	60	10	30
G2	50	20	30
G3	40	30	30
G4	20	60	20
G5	60	10	30
G6	50	20	30
G7	40	30	30
G8	20	60	20

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DISCUSSION

This *in vitro* study evaluated the shear bond strength of two universal adhesive systems, Single Bond Universal and Prime&Bond Universal, to dentin-bioactive material complexes incorporating four distinct base materials. The findings partially reject the null hypotheses, indicating that although no significant difference was found between the adhesive systems, the type of bioactive base material significantly influenced the bond strength.

TheraCal LC yielded the highest bond strength values among the materials tested. This outcome supports prior research indicating that its resin-modified calcium silicate composition contributes to improved micromechanical interlocking and enhanced polymer interaction at the interface.[10,18] More recent studies have also confirmed these findings, attributing the enhanced adhesion to the material's resin matrix and light-curing capabilities.[18] In addition, systematic reviews highlight the importance of appropriate material selection for direct pulp capping, particularly in terms of adhesive compatibility and sealing effectiveness.[19] In contrast, BioMTA+, a chemically set calcium silicate-based material, exhibited the lowest bond strength values. This may be due to its high porosity, long setting time, and the absence of polymerizable components, which impair hybrid layer formation and resin infiltration.[20] The cohesive failures observed in the BioMTA+ groups further suggest internal material fragility rather than inadequate adhesive bonding.

The intermediate performance of the Riva LC and Riva SC is consistent with their composition as glass ionomer-based materials. Although their polyalkenoic acid content and glass particles offer a certain amount of chemical bonding potential, their inherent hydrophilicity and water-based reactions may limit resin infiltration.[9,21] In particular, the TheraCal LC demonstrated favorable physical and biological properties for pulp capping, supporting its effective bonding performance.[22] These results underscore the importance of moisture control and material-adhesive compatibility in achieving optimal bond strength.

No significant difference was found between the two universal adhesive systems across all the materials. This aligns with evidence that current universal adhesives, especially those containing 10-MDP, perform consistently when applied according to manufacturer protocols.[12,13] Moreover, recent reviews emphasize that surface pretreatment often plays a greater role than adhesive formulation in determining bond strength.[16,17] Recent comparative studies have also demonstrated that the type of liner material significantly influences bonding performance. For example, calcium silicate-based materials such as TheraCal LC and Biodentine have been reported to exhibit higher bond strength values compared to MTA-based materials, largely due to their improved surface characteristics and resin-containing structure. Similarly, resin-modified glass ionomer cements have shown intermediate bonding performance, depending on their degree of polymerization and interaction with adhesive systems. These findings are consistent with the present results, further emphasizing that the substrate properties of liner materials are critical determinants of adhesive effectiveness. [23–27]

Thermal cycling, used to mimic intraoral conditions, may have accentuated differences in material durability. Previous studies report that thermocycling can compromise the resin–substrate interface, particularly in materials with high water uptake or poor mechanical integrity.[14] The significantly lower bond strengths in the BioMTA+ groups relative to the TheraCal LC and Riva LC are consistent with this phenomenon.

From a clinical perspective, the results emphasize the critical role of base material selection in deep cavity restorations. While universal adhesives offer procedural versatility, their effectiveness depends heavily on the underlying substrate. TheraCal LC, with its resin content and immediate light-curing, appears to provide an optimal bonding environment.[10,18] Conversely, calcium silicate-based materials lacking polymerizable components, such as BioMTA+, may require additional surface treatment to enhance bond strength.[20,28]

Despite the valuable insight gained from this study, several limitations should be acknowledged. The relatively limited sample size of this study should be acknowledged as a limitation, as it may have restricted the ability to fully characterise the effects of

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the tested variables. As an *in vitro* investigation, the results may not fully reflect the complex conditions of the oral environment, such as saliva contamination, mechanical loading, and patient-related variability. Additionally, only two universal adhesive systems and four base materials were tested, which may limit the generalizability of the findings. Future studies involving other adhesive formulations, extended aging protocols, and clinical evaluations are recommended to validate and expand upon these results.

CONCLUSION

Within the limitations of this *in vitro* study, it was concluded that the type of bioactive base material had a significant impact on bond strength, whereas the choice of universal adhesive did not. TheraCal LC showed the highest bond strength among all the tested materials. From a clinical perspective, the selection of resin-modified calcium silicate materials such as TheraCal LC may enhance adhesive performance in deep cavity restorations, while materials like BioMTA+ may require additional surface treatment to achieve optimal bonding outcomes.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

REFERENCES

1. Warreth A. Dental caries and its management. Int J Dent 2023;2023:9365845

2. Li Z, Yu C, Chen H. Global, regional, and national caries of permanent teeth incidence, prevalence, and disability-adjusted life years, 1990-2021: analysis for the global burden of disease study. BMC Oral Health 2025;25:715.

3. Hamilton AR, Ricketts D. Management of deep caries: Management of deep caries. Br Dent J 2026;240:357-64.

4.Lundbeck HJ, Pitchika V, Wilson P, Raggio DP, Galloway J, Al-Yaseen W, *et al.* Dental practitioners' thresholds for restorative intervention in carious lesions: a survey-based systematic review update. Caries Res 2026;60:65-79.

5. Ha HT, Kosmynina S, Verocq A, Ozen K, Tekia I, Bussy H, *et al.* Human atlas of tooth decay progression: identification of cellular mechanisms driving the switch from dental pulp repair toward irreversible pulpitis. Adv Sci 2026;13:e10096.

6. Khairy AM, Nasr RAT, Ali MM. Clinical and radiographic evaluation of premixed versus powder/liquid bioceramic mineral trioxide aggregate in indirect pulp capping of immature permanent mandibular molars: a randomized clinical trial. BMC Oral Health 2026;26:394.

7. Taha NA, Awwad AA, Hassouneh L, Alzraikat H. Investigating a calcium silicate-based cement as a dentine replacement material in permanent mandibular molars treated with full pulpotomy: a laboratory study of fracture strength and microleakage. J Dent 2026;169:106642.

8. Tsuchiya K, Sauro S, Sano H, Matinlinna JP, Yamauti M, Hoshika S, *et al.* Clinical applications and classification of calcium silicate-based cements based on their history and evolution: a narrative review. Clin Oral Investig 2025;29:187.

9. Tuygunov N, Abdurahimova F, Rizaeva S, Khurshid Z, Cahyanto A, Zakaria MN, *et al.* Effect of particle size reduction on the physicochemical and mechanical properties of conventional glass ionomer cement. Front Dent Med 2025;6:1714410.

10. Greene ZK, Smith NR, Gomes T, Lawson NC. Shear bond strength of liner materials to caries-free and caries-affected dentin. Oper Dent 2025;50:324-32.

11. Gao W, Fu Z, Pan W, *et al*. Dynamically crosslinking bio-inspired adhesives with high bond strength and multi-environmental adaptability for ultra-low temperature adhesion. Adv Funct Mater 2025;35:e11884.

12. Janson M, Sun L, Liebermann A, Schoppmeier CM. Impact of immediate dentin sealing with various universal adhesives on shear bond strength of dual-cure resin cement. Clin Exp Dent Res 2025;11:e70186.

13. Triani F, Pereira da Silva L, Ferreira Lemos B, Domingues J, Teixeira L, Manarte-Monteiro P. Universal adhesives: evaluation of the relationship between bond strength and application strategies- a systematic review and meta-analyses. Coatings. 2022;12:1501

14. Malysa A, Wezgowiec J, Grzebieluch W, Danel DP, Wieckiewicz M. Effect of thermocycling on the bond strength of self-adhesive resin cements used for luting CAD/CAM ceramics to human dentin. Int J Mol Sci 2022;23:745.

15. Polesso Patias M, Fernandes-E-Silva P, Carreño NLV, Lund RG, Piva E, da Silva AF, *et al.* Comparative clinical performance of universal adhesives versus etch-and-rinse and self-etch adhesives: a meta-analysis. Clin Oral Investig 2025;29:352.

16. Hardan L, Bourgi R, Kharouf N, Mancino D, Zarow M, Jakubowicz N, *et al.* Bond strength of universal adhesives to dentin: meta-analysis. Polymers 2021;13:814.

17. Meng Y, Huang F, Wang S, Li M, Lu Y, Pei D, *et al.* Bonding performance of universal adhesives applied to nano-hydroxyapatite desensitized dentin using etch-and-rinse or self-etch mode. Materials 2021;14:4746.

18. Dulger K, Kosar T. Comparison of three dentine replacement materials in terms of different characteristics. Aust Endod J 2025;51:81-9.

19. Gomez-Sosa JF, Granone-Ricella M, Rosciano-Alvarez M, Barrios-Rodriguez VD, Goncalves-Pereira J, Caviedes-Bucheli J. Determining factors in the success of direct pulp capping: a systematic review. J Contemp Dent Pract 2024;25:392-401.

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20. Hussein MA, Jehad RH. Removal efficiency of mineral trioxide aggregate: a narrative review of retrieval techniques. J Med Oral Biosci 2025;2:36-50.

21. Abozaid D, Elwakeel E, Mohamed MA, Bahnsawy MA, Eldebawy M, Elraggal A, *et al.* Effects of propolis-modified glass ionomer cement on antimicrobial activity and physico-mechanical properties: a systematic review. Odontology 2026;468-493

22. Hernández-Cabanillas JC, Hardan L, Cuevas-Suárez CE, Olivares-Acosta I, Dang AT, Tosco V, *et al*. Comparative evaluation of the physicochemical and biological properties of calcium silicate-based pulp capping materials. Front Dent Med 2025;6:1737941.

23. Gündoğar ZU, Keskin G, Yaman Küçükersen M. Shear bond strength of biointeractive restorative materials to NeoMTA Plus and Biodentine. Polymers. 2025;17:3070.

24. Hardan L, Mancino D, Bourgi R, Alvarado-Orozco A, Rodriguez-Vilchis LE, Flores-Ledesma A, *et al*. Bond strength of adhesive systems to calcium silicate-based materials: a systematic review and meta-analysis of *in vitro* studies. Gels 2022;8:311.

25. Foly JCSDN, Weissheimer M, Gaspar CF, Fehrenbach J, Miotti LL, Piva E, *et al.* Bonding performance of universal adhesive systems to enamel–effects of the acidic composition. Dent Mater 2025;41:272-82.

26. Elshaishai MY, Al-Ansary HI, Hassanien EEY. Effect of bioactive cement versus MDP-containing resin cement on shear bond strength of super high translucent zirconia to dentin (an in-vitro study). Adv Dent J 2024;6:735-48.

27. Candan M, Altinay Karaca FK, Öznurhan F. Evaluation of the shear bond strength of immediate and delayed restorations of various calcium silicate-based materials with fiber-reinforced composite resin materials. Polymers 2023;15:3971.

28. Falakaloğlu S, Yeniçeri Özata M, Plotino G. Micro-shear bond strength of calcium silicate materials to bulk-fill composite. PeerJ 2023;11:e15183.

Biyoaktif Kavite Taban Materyallerinin Universal Adezivlerin Dentine Bağlanma Dayanımı Üzerine Etkisi

ÖZET

Amaç: Bu *in vitro* çalışma, farklı biyoaktif taban maddelerinin, dentin-taban kompleksi üzerine uygulandığında iki evrensel adeziv sistemin (Single Bond Universal ve Prime&Bond Universal) bağlanma dayanıklılığı üzerindeki etkisini araştırmayı amaçlamaktadır. Adezivler ile taban maddeleri arasındaki etkileşimin anlaşılması, derin kavitelerde yapılan restorasyonların uzun ömürlülüğünün artırılması açısından önemlidir.

Gereç ve Yöntemler: Seksen adet çekilmiş insan molar dişi kesilerek standart dentin yüzeyleri hazırlandı. Dört farklı biyoaktif taban maddesi (TheraCal LC, Riva LC, Riva SC ve BioMTA+) uygulandı, ardından iki evrensel adezivden biri kullanıldı. Kompozit bloklar yerleştirildikten sonra örnekler, oral yaşlanmayı simüle etmek için 10.000 termal döngüye tabi tutuldu. Makaslama bağlanma dayanıklılığı (SBS) testi gerçekleştirildi ve kırılma tipleri mikroskop altında analiz edildi. İki yönlü ANOVA ve Tukey'nin post hoc testleri uygulandı ($\alpha = 0.05$).

Bulgular: Taban maddesi tipi, bağlanma dayanıklılığı üzerinde istatistiksel olarak anlamlı bir etki göstermiştir ($p < 0.001$), ancak adeziv markası anlamlı fark oluşturmamıştır ($p = 0.247$). TheraCal LC en yüksek ortalama bağlanma dayanıklılığına (20.6 ± 2.1 MPa) sahipken, BioMTA+ en düşük değeri göstermiştir (10.2–11.4 MPa). Kırılma modu analizinde, BioMTA+ grubunda baskın olarak koheziv kırılmalar gözlenmiş, bu durum materyalin içsel zayıflığına işaret etmiştir.

Sonuç: Evrensel adezivlerin bağlanma dayanıklılığı, seçilen biyoaktif taban maddesinden önemli ölçüde etkilenmektedir. TheraCal LC, reçine ile modifiye edilmiş yapısı ve ışıkla sertleşme özelliği sayesinde üstün performans sergilemiştir. Test edilen iki adeziv arasında anlamlı fark saptanmamıştır.

Anahtar Kelimeler: Bioaktif materyaller; Cam iyonomer siman;Dentin bonding; Makaslama bağlanma dayanımı; Universal adezivler

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Original Research Article

Pediatric Dentists' Preferences for Local Anesthesia Use under General Anesthesia: A Cross-sectional Study

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ABSTRACT

Aim: General anesthesia (GA) is a widely used behavior management technique for pediatric patients unable to tolerate dental treatment in conventional settings. However, there is no established consensus on the routine use of local anesthesia during dental procedures under GA. Conflicting evidence regarding its benefits and risks continues to influence clinical practice. This study aims to explore pediatric dentists' preferences regarding local anesthesia (LA) administration during GA and to identify the factors affecting their decisions.

Materials and Methods: A twenty-item survey, the Pediatric Dentists' Local Anesthesia Preference Questionnaire (PD-LAPQ), was specifically developed and validated for this study. Content and face validity were confirmed through expert review and pilot testing. The questionnaire assessed demographics, clinical preferences, and rationale for LA use or avoidance. A convenience sample of pediatric dentists was invited to participate. Statistical analyses included Chi-squared, Mann-Whitney U, and Kruskal-Wallis tests ($p < 0.05$).

Results: Of the 450 invited dentists, 210 responded (46.7%). Of these, 20% always used LA under GA, 1.9% never used it, and 78.1% used it on a case-by-case basis. Most respondents were female (90.5%) with over five years of clinical experience (70.5%). 20% of participants reported always using LA during procedures performed under GA, while 1.9% reported never using it. No statistically significant association was found between the use of LA and the participants' gender, years of experience, or institutional setting.

Conclusion: Findings reveal considerable variation in LA practices under GA among pediatric dentists. Developing standardized, evidence-based guidelines could enhance clinical decision-making and promote safer, more consistent patient care.

Keywords: Dental treatment; General anesthesia; Local anesthesia; Pediatric dentistry

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INTRODUCTION

General anesthesia (GA) is a commonly used behavior management technique that allows dentists to provide dental care to children who cannot tolerate treatment in a routine clinical setting.[1] Although GA ensures a safe and pain-free experience, children may still experience discomfort during emergence from GA.[2,3] Pain is the most frequently reported postoperative complication in pediatric dental procedures performed under GA.[4,5] A number of researchers suggest that using local anesthesia (LA) during these procedures may help control pain and bleeding as well as reducing physiological stress, such as increased heart rate.[6,7,8]

Despite these potential benefits, the current literature presents inconsistent findings. A number of studies report that the use of LA during GA does not significantly reduce postoperative pain and may increase the risk of soft tissue injuries, such as lip and cheek biting. [9,10] Although this complication has raised concerns, no clear evidence has established a strong link between LA use and soft tissue trauma.[4,10] A study by Watts *et al*.[11] reports that the use of

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LA lowered end-tidal CO_2 levels, heart rate, and the need for physician intervention after tooth extraction, although the authors note that these physiological changes may not be clinically important in healthy children. As a result, no clear consensus exists regarding the routine use of LA during dental procedures performed under GA.[4,7,12-14]

Although evidence-based guidelines exist for managing dental pain following trauma and surgical procedures in the general population[15,16], specific recommendations for children receiving dental treatment under general anesthesia remain limited. The guideline titled 'Guidelines for the Management of Children Referred for Dental Extractions Under General Anaesthesia', published by the British Society of Paediatric Dentistry (BSPD), focuses exclusively on extractions and discusses the potential advantages and disadvantages of local anesthesia use, ultimately leaving the decision to the clinical judgment of the dental practitioner.[17]

The use of LA during dental procedures under GA remains a subject of debate, as the decision often relies on the individual preferences of pediatric dentists. While certain studies have examined these preferences, much of the available research is more than a decade old.[18-20] Given the introduction of new anesthetic agents and evolving clinical protocols, updated studies are needed to provide insight relevant to current practice. Therefore, the aim of this study is to investigate pediatric dentists' preferences for using LA during dental procedures under GA and to identify the factors that influence their decision-making.

MATERIALS AND METHODS

This cross-sectional online-based questionnaire survey study was conducted between March and May 2024, and reported according to the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) guidelines. The study protocol was approved by the Ethics Committee of Lokman Hekim

University (Approval number: 2023/253) and adhered to the principles outlined in the Declaration of Helsinki.

The survey incorporated the following methodological safeguards: (1) participant anonymity was maintained by not collecting any email addresses or personally identifiable information; (2) multiple submissions were prevented by requiring an email-based login, allowing only one response per participant; and (3) all questions were marked as mandatory to ensure complete data collection and the participants were unable to submit the survey unless all items were answered. Additionally, elements of the STROBE checklist for cross-sectional studies were incorporated to maintain methodological rigor.

Following a review of previous studies[18-20], an online questionnaire entitled the Pediatric Dentists' Local Anesthesia Preference Questionnaire (PD-LAPQ) was developed for this study. An English version of the PD-LAPQ is provided in Supplementary File 1. To ensure clarity and comprehensiveness, a preliminary version of the questionnaire was administered to ten pediatric dentists who routinely treat children under general anesthesia. Based on the feedback received, the survey was revised to improve its structure and content.

Content validity was established through expert evaluation by experienced professionals in the field. Face validity was assessed through a separate pilot test involving thirty pediatric dentists, focusing on the clarity and usability of the questionnaire. Reliability was evaluated using the test-retest method: thirty pediatric dentists completed the questionnaire twice, with a two-week interval between administrations. The intraclass correlation coefficient (ICC) was 0.89, indicating excellent response stability over time. Additionally, a Cronbach's alpha of 0.80 demonstrated good internal consistency, confirming that the instrument reliably measured pediatric dentists' attitudes toward the use of LA during dental procedures under GA.

According to the Turkish Dental Association, there are 818 pediatric dentists nationwide.[21] This study targeted pediatric dentists working in the public, private, and academic sectors in various cities in Türkiye. Pediatric dentists who perform dental rehabilitation under GA and voluntarily agreed to participate were included in the study. The sample size was determined using G*Power 3.1.9.2. Based on a 95% confidence level (alpha = 0.05), a Cohen's w effect size of 0.32 (medium effect) derived from a similar previous study[18], and a chi-square test with 1 degree of freedom, a minimum of 77 participants was need-

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ed to achieve a statistical power of 0.80. Considering that previous studies have reported response rates ranging from 17% to 42%, a conservative estimate of 17% was adopted.[18-20] Therefore, to reach the target sample size, the questionnaire was distributed to at least 450 pediatric dentists.

The participants were recruited using a convenience sampling approach. A twenty-question survey was created on Google Forms, and distributed to pediatric dentists through the national offices of the Turkish Society of Pediatric Dentistry (TSPD) and the Turkish Dental Association (TDA). The invitation email included a cover letter introducing the investigators, outlining the study's objectives, and assuring the participants of confidentiality. The introduction page of the survey also provided information regarding the voluntary nature of participation, data privacy, as well as the potential risks and benefits. Informed consent was obtained electronically before the participants began the survey. To enhance participation, a reminder email was sent two weeks after the initial invitation.

The questionnaire consisted of four sections. The first section addressed the participants' demographic and professional characteristics, including gender, years of experience, and type of institution. The remaining sections explored various aspects of LA use during dental procedures under GA, including its frequency, the clinical scenarios in which it was administered, and the underlying reasons for its use. The participants were also asked to specify the type of anesthetic agent used, the timing of the administration, and the technique employed.

The data were analyzed using SPSS 22.0 software (SPSS Inc., Chicago, IL, USA). Since the data were not normally distributed, nonparametric tests, the Mann–Whitney U and Kruskal-Wallis tests, were used for group comparisons. Categorical variables were analyzed using the Chi-squared and Fisher's exact tests. The Spearman's rank correlation was used to examine associations between continuous variables. Since each survey item was compared across three sociodemographic variables (gender, years of experience, and institution type), a Bonferroni correction was applied within each comparison family, yielding a corrected significance threshold of $\alpha = 0.0167$ (0.05/3). A p-value of < 0.05 was considered statistically significant.

RESULTS

The questionnaire was distributed by email to 450 pediatric dentists, yielding 210 responses and a response rate of 46.7%. Among the 210 participants, 190 (90.5%) were female, and 20 (9.5%) were male. Most participants (148/210, 70.5%) reported having more than five years of professional experience as pediatric dentists. Regarding institutional affiliation, 114 (54.3%) were employed in university hospitals, 77 (36.7%) worked in private clinics, and 19 (9%) were based in public hospitals. The demographic and professional characteristics of the participants are summarized in Table 1.

Regarding the use of LA during dental procedures under GA, forty-two of the participants (20%) reported always using it, ninety-one (43.3%) used it more than half the time, seventy-three (34.8%) used it less than half the time, and four (1.9%) stated that they never used it. No statistically significant association was found between the overall frequency of LA use and the participants' gender, years of experience, or institutional setting. Among those who reported using LA, articaine was the most frequently preferred anesthetic (149/210, 71%), followed by lidocaine (56/210, 26.7%) and bupivacaine (1/210, 0.5%). Additionally, almost all of the participants (200/210, 95.2%) reported using LA with epinephrine. The choice of anesthetic agent did not differ according to the administration technique or application site. Similarly, no statistically significant associations were found between the anesthetic preference and the participants' demographic or professional characteristics (Table 2).

Table 1. The demographic and professional characteristics of the participants

Gender	**n**	**%**
Male	20	9.5
Female	190	90.5
Experience		
0-5	62	29.5
>5	148	70.5
Institution		
University hospitals	114	54.3
Private offices	77	36.7
Public hospitals	19	9

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Table 3 presents the preferences of the pediatric dentists regarding LA administration techniques across different anatomical regions. Infiltration anesthesia was the most commonly used technique in the upper and lower incisor regions (198/210, 94.3%), as well as in the lower molar region (148/210, 70.5%). Similarly, in the upper molar region, infiltration anesthesia was the most frequently preferred technique (193/210, 91.9%). Although a difference was noted between years of experience and the preferred technique in the upper molar region, with infiltration used by 138 of the 148 dentists (93.2%) with more than five years of experience compared to 55 of the 62 dentists (88.7%) with less experience, this association did not remain statistically significant after Bonferroni correction (p = 0.03; corrected α = 0.0167)

Table 2. The participants' preferences for the type of local anesthetic

		Gender n (%)		Experience n (%)		Institution n (%)		
	Total	**Male**	**Female**	**0-5yr**	**>5yr**	**University hospitals**	**Private offices**	**Public hospitals**
Articaine	149 (71.0)	14 (70.0)	135(71.1)	38 (61.3)	111 (75.0)	78 (68.4)	55 (71.4)	16 (84.2)
Lidocaine	56 (26.7)	5 (25.0)	51 (26.8)	22 (35.5)	34 (23.0)	33 (28.9)	20 (26.0)	3 (15.8)
Bupivacaine	1 (0.5)	0 (0.0)	1 (0.5)	1 (1.6)	0 (0.0)	0 (0.0)	1 (1.3)	0 (0.0)
I never administer it	4 (1.9)	1 (5.0)	3 (1.6)	1 (1.6)	3 (2.0)	3 (2.6)	1 (1.3)	0 (0.0)
p		0.51	0.07	0.69				
LA with epinephrine	200 (95.2)	18 (90.0)	182 (95.8)	60 (96.8)	140 (94.6)	106 (93.0)	75 (97.4)	19 (100.0)
LA without epinephrine	6 (2.9)	1 (5.0)	5 (2.6)	0 (0.0)	6 (4.1)	4 (3.5)	2 (2.6)	0 (0.0)
I never administer it	4 (1.9)	1 (5.0)	3 (1.6)	2 (3.2)	2 (1.4)	4 (3.5)	0 (0.0)	0 (0.0)
p		0.24	0.20	0.53				

Due to low expected cell counts, group comparisons were performed using Fisher's exact test. For multi-category contingency tables, the Fisher–Freeman–Halton exact test was applied. Significance level p < 0.05 (uncorrected); Bonferroni-corrected threshold α = 0.0167 within each comparison family.

Table 3. The participants' preferences for local anesthesia techniques by anatomical regions

		Gender n (%)		Experience n (%)		Institution n (%)		
	Total	**Male**	**Female**	**0-5yr**	**>5yr**	**University hospitals**	**Private offices**	**Public hospitals**
Upper and lower incisor region								
Infiltration	198(94.3)	16 (90)	180(94.7)	59 (95.2)	139(93.6)	106 (93.0)	73 (94.8)	19 (100)
Regional nerve block	1 (0.5)	0 (0.0)	1 (0.5)	0 (0.0)	1 (0.7)	1 (0.9)	0 (0.0)	0 (0.0)
Intraligamentary	3 (1.4)	0 (0.0)	3 (1.6)	0 (0.0)	3 (2.0)	1 (0.9)	2 (2.6)	0 (0.0)
Intraosseous	1 (0.5)	0 (0.0)	1 (0.5)	0 (0.0)	1 (0.7)	0 (0.0)	1 (1.3)	0 (0.0)
Do not prefer	7 (3.3)	2 (10)	5 (2.6)	3 (4.8)	4 (2.7)	6 (5.3)	1 (1.3)	0 (0.0)
p		0.38	0.73	0.55				
Lower molar region								
Infiltration	148 (70.5)	11 (55.0)	137(72.1)	36 (58.1)	112(75.7)	82 (71.9)	53 (68.8)	13 (68.4)
Regional nerve block	46 (21.9)	8 (40.0)	38 (20.0)	20 (32.3)	26 (17.6)	22 (19.3)	19 (24.7)	5 (26.3)
Intraligamentary	9 (4.3)	0 (0.0)	9 (4.7)	3 (4.8)	6 (4.1)	5 (4.4)	3 (3.9)	1 (5.3)
Intraosseous	1 (0.5)	0 (0.0)	1 (0.5)	0 (0.0)	1 (0.7)	0 (0.0)	1 (1.3)	0 (0.0)
Do not prefer	6 (2.9)	1 (5.0)	5 (2.6)	3 (4.8)	3 (2.0)	5 (4.4)	1 (1.3)	0 (0.0)
p		0.20	0.06	0.78				
Upper molar region								
Infiltration	193 (91.9)	19 (95.0)	174(91.6)	55(88.7)	138(93.2)	104 (91.2)	71(92.2)	18 (94.7)
Regional nerve block	5 (2.4)	0 (0.0)	5 (2.6)	4 (6.5)	1 (0.7)	3 (2.6)	2 (2.6)	0 (0.0)
Intraligamentary	5 (2.4)	0 (0.0)	5 (2.6)	0 (0.0)	5 (3.4)	2 (1.8)	2 (2.6)	1 (5.3)
Intraosseous	1 (0.5)	0 (0.0)	1 (0.5)	0 (0.0)	1 (0.7)	0 (0.0)	1 (1.3)	0 (0.0)
Do not prefer	6 (2.9)	1 (5.0)	5 (2.6)	3 (4.8)	3 (2.0)	5 (4.4)	1 (1.3)	0 (0.0)
p		0.83	0.03	0.71				

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Table 4 presents the pediatric dentists' preferences for using LA in various dental procedures. A statistically significant association was observed between the years of experience and the use of LA for composite or compomer restorations (p = 0.001). Among dentists with more than five years of experience, only seven (4.7%) reported using LA for these procedures, compared to twelve (19.4%) of those with less experience. In addition, a trend was observed between the preference for using LA during primary tooth extractions and the type of institution, although this did not remain significant after Bonferroni correction (p = 0.02; corrected α = 0.0167). While 14% of the university-based dentists (16/114) reported not using LA for primary tooth extractions, this rate was only 3.9% among those in private practice (3/77). Notably, all the respondents employed in public hospitals reported consistently using LA for primary tooth extractions.

Table 4. The participants' preferences for local anesthesia use across different dental procedures

			Gender n (%)		Experience n (%)		Institution n (%)		
		Total	**Male**	**Female**	**0-5**	**>5**	**University hospitals**	**Private offices**	**Public hospitals**
Permanent teeth extraction	Prefer	202(96.2)	19 (95.0)	183(96.3)	59 (95.2)	143 (96.6)	108 (94.7)	75 (97.4)	19 (100.0)
	Do not prefer	8 (3.8)	1 (5.0)	7 (3.7)	3 (4.8)	5 (3.4)	6 (5.3)	2 (2.6)	0 (0.0)
	p		0.56	0.67	0.43				
Primary teeth extraction	Prefer	191(91.0)	19 (95.0)	172(90.5)	54 (87.1)	137 (92.6)	98 (86.0)	74 (96.1)	19 (100.0)
	Do not prefer	19 (9.0)	1 (5.0)	18 (9.5)	8 (12.9)	11 (7.4)	16 (14.0)	3 (3.9)	0 (0.0)
	p		1.0	0.21	0.02				
Composite or compomer restoration	Prefer	19 (9.0)	3 (15.0)	16 (8.4)	12 (19.4)	7 (4.7)	8 (7.0)	9 (11.7)	2 (11.7)
	Do not prefer	191(91.0)	17 (85.0)	174(91.6)	50 (80.6)	141 (95.3)	106 (93.0)	68 (88.3)	17 (89.5)
	p		0.40	<0.01	0.53				
Stainless steel crowns	Prefer	58 (27.6)	7 (35.0)	51 (26.8)	17 (27.4)	41 (27.7)	28 (24.6)	22 (28.6)	8 (42.1)
	Do not prefer	152(72.4)	13 (65.0)	139(73.2)	45 (72.6)	107 (72.3)	86 (75.4)	55 (71.4)	11 (57.9)
	p		0.44	0.97	0.28				
Prefabricated zirconia crowns	Prefer	95 (45.2)	8 (40.0)	87 (45.8)	24 (38.7)	71 (48.0)	45 (39.5)	38 (49.4)	12 (63.2)
	Do not prefer	115(54.8)	12 (60.0)	103(54.2)	38 (61.3)	77 (52.0)	69 (60.5)	39 (50.6)	7 (36.8)
	p		0.62	0.22	0.10				
Total/partial pulpotomies	Prefer	77 (36.7)	9 (45.0)	68 (35.8)	26 (41.9)	51 (34.5)	41 (36.0)	29 (37.7)	7 (36.8)
	Do not prefer	133(63.3)	11 (55.0)	122(64.2)	36 (58.1)	97 (65.5)	73 (64.0)	48 (62.3)	12 (63.2)
	p		0.42	0.31	0.97				
Root canal treatment of permanent teeth	Prefer	96 (45.7)	10 (50.0)	86 (45.3)	30 (48.4)	66 (44.6)	48 (42.1)	40 (51.9)	8 (42.1)
	Do not prefer	114(54.3)	10 (50.0)	104(54.7)	32 (51.6)	82 (55.4)	66 (57.9)	37 (48.1)	11 (57.9)
	p		0.69	0.62	0.39				
Root canal treatment of primary teeth	Prefer	84 (40)	7 (35.0)	77 (40.5)	28 (45.2)	56 (37.8)	41 (36.0)	35 (45.5)	8 (42.1)
	Do not prefer	126 (60)	13 (65.0)	113(59.5)	34 (54.8)	92 (62.2)	73 (64.0)	42 (54.5)	11 (57.9)
	p		0.63	0.32	0.41				

Significance level p < 0.05 (uncorrected); Bonferroni-corrected threshold α = 0.0167 within each comparison family.

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Table 5. The participants' reasons for using local anesthesia during dental treatment under general anesthesia.

		Gender n (%)		Experience n (%)		Institution n (%)		
	Total	**Male**	**Female**	**0-5**	**>5**	**University hospitals**	**Private offices**	**Public hospitals**
Hemorrhage control	175 (83.3)	16 (80.0)	159 (83.7)	48 (77.4)	127 (85.8)	92 (80.7)	66 (85.7)	17 (89.5)
p		0.75	0.16	0.59				
Postoperative pain control	167 (79.5)	16 (80.0)	151 (79.5)	46 (74.2)	121 (81.8)	86 (75.4)	63 (81.8)	18 (94.7)
p		1.0	0.26	0.12				
Stabilization of vital signs/protection of the general anesthesia's depth	125 (59.5)	12 (60.0)	113 (59.5)	37 (59.7)	88 (59.5)	65 (57.0)	47 (61.0)	13 (68.4)
p		1.0	1.0	0.629				
Request of the anesthesiologist	13 (6.2)	0 (0.0)	13 (6.8)	3 (4.8)	10 (6.8)	7 (6.1)	4 (5.2)	2 (10.5)
p		0.62	0.76	0.63				
Improved patient recovery	11 (5.2)	1 (5.0)	10 (5.3)	5 (8.1)	6 (4.1)	7 (6.1)	4 (5.2)	0 (0.0)
p		1.0	0.31	0.81				

Significance level $p < 0.05$ (uncorrected); Bonferroni-corrected threshold $\alpha = 0.0167$ within each comparison family. Physicians may have reported more than one reason

Table 6. The participants' concerns regarding the use of local anesthesia during dental procedures under general anesthesia

		Gender n (%)		Experience n (%)		Institution n (%)		
	Total	**Male**	**Female**	**0-5**	**>5**	**University hospitals**	**Private offices**	**Public hospitals**
Postoperative lip and cheek biting	148 (70.5)	16 (80.0)	132 (69.5)	35 (56.5)	113 (76.4)	76 (66.7)	58 (75.3)	14 (73.7)
p		0.36	<0.01	0.42				
Increases patient agitation on recovery	73 (34.8)	8 (40.0)	65 (34.2)	18 (29.0)	55 (37.2)	37 (32.5)	32 (41.6)	4 (21.1)
p		0.61	0.26	0.18				
Increased risk of toxic/ allergic reaction	52 (24.8)	4 (20.0)	48 (25.3)	21 (33.9)	31 (20.9)	33 (28.9)	15 (19.5)	4 (21.1)
p		0.79	0.05	0.31				
Risk of interaction between LA and general anesthetics	37 (17.6)	4 (20.0)	33 (17.4)	11 (17.7)	26 (17.6)	24 (21.1)	13 (16.9)	0 (0.0)
p		0.76	0.98	0.08				
Unnecessary for post-operative pain control	15 (7.1)	3 (15.0)	12 (6.3)	3 (4.8)	12 (8.1)	8 (7.0)	7 (9.1)	0 (0.0)
p		0.16	0.56	0.47				

Significance level $p < 0.05$ (uncorrected); Bonferroni-corrected threshold $\alpha = 0.0167$ within each comparison family. Physicians may have reported more than one reason

The most commonly reported reason for LA use under GA was hemorrhage control (83.3%, 175/210), followed by postoperative pain control (79.5%, 167/210) and the stabilization of vital signs to maintain anesthetic depth (59.5%, 125/210). Fewer respondents cited anesthesiologist request (6.2%, 13/210) or improved patient recovery (5.2%, 11/210) as their rationale (Table 5).

In parallel with these motivations, the participants were also asked to report their concerns regarding LA use under GA. The most frequently cited concern was postoperative lip and cheek biting (70.5%, 148/210), followed by patient agitation during recovery (34.8%, 73/210), the risk of toxic or allergic reactions (24.8%, 52/210), and potential interaction between LA and general anesthetics (17.6%,

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37/210). A smaller proportion of the participants (7.1%, 15/210) considered LA unnecessary for postoperative pain control. A statistically significant association was found between experience level and concern with regard to postoperative lip and cheek biting ($p < 0.01$); 76.4% of the dentists with more than five years of experience (113/148) expressed this concern, compared to 56.5% (35/62) of those with less experience. A similar trend was observed for concerns about toxic or allergic reactions, which were more frequently reported by experienced dentists, although this association did not remain significant after Bonferroni correction ($p = 0.048$; corrected $\alpha = 0.0167$) (Table 6).

DISCUSSION

Although LA is frequently used during dental procedures under GA, the literature provides inconclusive evidence regarding its overall clinical benefits, including postoperative pain reduction, bleeding control, and stabilization of vital signs.[4,8] This study contributes to the ongoing discussion by examining pediatric dentists' preferences and decision-making patterns. In this study, 20% of the respondents reported always using LA, 1.9% stated they never used it, and the majority, 78.1%, indicated that their decisions were made on a case-by-case basis. Additionally, 96.2% reported using LA during permanent tooth extractions under GA, while 3.8% did not use it. Even though clinical guidelines lack a definitive stance on this issue, the invasive nature of permanent tooth extraction makes the absence of LA use in such cases a topic worthy of critical discussion.

This variability may be further shaped by the lack of standardized GA protocols across institutions. Significant differences exist among healthcare centers in the choice of induction and maintenance agents, airway management approaches, and monitoring strategies. Anesthetic agents are often administered alone or in combination to maintain intraoperative stability. Each pharmacological regimen may elicit distinct responses to surgical stimuli, thereby influencing anesthetic depth and the effectiveness of postoperative pain control. As a result, such variations in anesthetic management may have a considerable impact on clinical decisions regarding the use of LA.

Previous studies have also demonstrated variability in pediatric dentists' preferences regarding LA use under GA. One study conducted among members of the American Academy of Pediatric Dentistry (AAPD) reported that 8% of respondents 'always' used LA under GA, whereas 21% 'never' used it.[18] Another study found that 40% of its participants consistently administered LA, while 10% reported never using it.[19] In a more recent investigation, approximately 65.5% of respondents favored the use of LA, citing advantages such as reduced intraoperative bleeding, improved procedural quality, and decreased postoperative pain upon awakening. In contrast, 34.5% opposed LA use due to concerns in regard to soft tissue injuries, hemodynamic fluctuations, prolonged recovery, and the perceived risk of overdose compared to outpatient procedures.[20]

In the present study, articaine was identified as the most commonly preferred local anesthetic among pediatric dentists. In contrast, previous surveys conducted among members of the American Academy of Pediatric Dentistry (AAPD) and the American Society of Dentist Anesthesiologists (ASDA) reported lidocaine as the most frequently used agent.[18,19] This variation in preference may stem from differences in dental education curricula, as well as the accessibility or regulatory approval of certain anesthetic agents in different countries. Although articaine is valued for its ability to diffuse through both hard and soft tissues, systematic reviews have not demonstrated its superiority over lidocaine in pediatric procedures.[14,22] Additionally, concerns regarding a higher incidence of paresthesia associated with articaine may influence clinical preference. Lidocaine, with its well-established safety profile and lower risk of nerve-related adverse effects, remains a more conservative choice in pediatric dentistry.[14,23]

The present study demonstrates that infiltration is the most commonly preferred administration technique across all anatomical regions. This finding is in line with previous studies reporting infiltration as the dominant approach for LA delivery in pediatric dental procedures.[18-20] Furthermore, the type of dental procedure significantly influenced LA use, with the participants most frequently opting for it during permanent and primary tooth extractions. This is con-

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sistent with the findings of Townsend *et al*.[18], who report that pediatric dentists commonly consider LA essential for extractions.[18]

According to the findings of this study, the pediatric dentists most often cited hemorrhage control, postoperative pain management, and stabilization of vital signs as the primary reasons for using LA during GA procedures. Notably, 79.5% of the respondents identified postoperative pain control as their main rationale. Similarly, Faghihian *et al*.[20] reported that 65% of pediatric dentists consider LA effective for managing postoperative pain. However, current evidence does not conclusively support the effectiveness of LA in reducing postoperative pain in pediatric patients undergoing extractions under GA.[24,25] Despite this, a number of researchers advocate for its use due to its hemostatic properties and its potential to stabilize intraoperative physiological responses, particularly in medically compromised children.[18,19]

This study presents several limitations that should be considered when interpreting the findings. First, the generalizability of the results is limited by the sample size. Although approximately 818 pediatric dentists practice in Türkiye[21], only 210 participated in the study, which may reduce the representativeness of the sample. Second, the relatively modest response rate (46.6%) raises concerns regarding nonresponse bias. Third, the voluntary nature of participation may have introduced self-selection bias, as individuals with strong opinions, either in favor of or against the use of LA under GA, may have been more likely to participate. Fourth, despite efforts to recruit participants from diverse practice settings to minimize selection bias, certain demographic imbalances remained. For example, the sample was predominantly female (90.5%) which, although it may reflect the gender distribution of pediatric dentists in Türkiye, could limit the broader applicability of the findings. Another limitation of the present study concerns multiple comparisons. Given the large number of statistical tests performed (78 comparisons across sociodemographic variables), a Bonferroni correction was applied within each comparison family (corrected $\alpha = 0.0167$). Consequently, several associations that appeared nominally significant at the conventional threshold ($p < 0.05$) — including those related to LA technique preference in the upper molar region, institutional differences in primary tooth extraction practice, and concerns regarding toxic or allergic reactions — did not remain statistically significant after correction. These findings should therefore be interpreted as exploratory trends rather than confirmed associations.

Future research should address the current study's limitations through several key approaches. First, investigations incorporating larger, more demographically diverse samples with balanced gender representation would enhance the generalizability of findings. Multicenter and multinational studies encompassing pediatric dentists from various healthcare systems could illuminate regional variations and establish global practice patterns regarding LA administration during GA procedures. Additionally, future survey designs should include items that assess the specific GA protocols used, such as the choice of induction and maintenance agents, airway management techniques, and intraoperative monitoring strategies as these factors may influence decisions regarding LA administration and affect perioperative outcomes.

CONCLUSION

In conclusion, the findings of this study highlight a lack of consensus on the use of LA during GA, suggesting a need for standardized clinical guidelines to optimize patient outcomes. While LA administration is widely used for its potential benefits, such as postoperative pain control, hemorrhage management, and stabilization of vital signs, its necessity in every GA case remains debatable. Understanding the specific conditions in which LA use is clinically beneficial could help prevent unnecessary administration and minimize potential complications, such as soft tissue injuries due to postoperative numbness.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest in relation to this study.

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REFERENCES

1. American Academy of Pediatric Dentistry. Behavior guidance for the pediatric dental patient. The Reference Manual of Pediatric Dentistry. Chicago, Ill.: American Academy of Pediatric Dentistry 2023:359-77.

2. Kakti A, Abumelha RK, Alajmi AM, Dagriri LK, Alkodari LA, Fares MJ, *et al*. Postoperative pain of pediatric patients undergoing dental treatment under general anesthesia visiting a general hospital: A cross-sectional study. Children 2023;10:671.

3. Hu YH, Tsai A, Ou-Yang LW, Chuang LC, Chang PC. Postoperative dental morbidity in children following dental treatment under general anesthesia. BMC Oral Health 2018;18:84.

4. Ting EXY, Sethi S, Jensen E, Poirier B. Pharmacological postoperative pain management for pediatric dental extractions under general anesthesia: A systematic review. Pain Res Manag 2025;8569846:1-13.

5. Brailo V, Janković B, Gabrić D, Lozić M, Stambolija V, Vidović, *et al*. Post-discharge complications of dental treatment in general anesthesia performed in a day-care service. Acta Stomatol Croat 2021;55:168–76.

6. Turan Y, Senirkentli GB, Cekmen N, Tirali E, Çakmak E. Retrospective evaluation of the effects of local anesthesia before tooth extraction procedures under general anesthesia on physiologic parameters and postoperative bleeding in children. Niger J Clin Pract 2024;27:723-31.

7. Parekh S, Gardener C, Ashley PF, Walsh T. Intraoperative local anesthesia for reduction of postoperative pain following general anesthesia for dental treatment in children and adolescents. Cochrane Database Syst Rev 2014;12:CD009742.

8. Leong KJ, Roberts GJ, Ashley PF. Perioperative Local Anesthetic in Young Paediatric Patients Undergoing Extractions under Outpatient 'short-Case' General Anesthesia. A Double-Blind Randomised Controlled Trial Br Dent J 2007;203:11.

9. Batarseh AR. Effect of local anesthesia on postoperative pain and hemostasis after dental rehabilitation under general anesthesia in pediatric patients: A randomized control trial. J Dent Anesth Pain Med 2023;23:337-46.

10. Coulthard P, Rolfe S, Mackie IC, Gazal G, Morton M, Jackson-Leech J. Intraoperative local anesthesia for pediatric postoperative oral surgery pain: A randomized controlled trial. Int J Oral Maxillofac Surg 2006;35:1114-9.

11. Watts AK, Thikkurissy S, Smiley M, McTigue DJ, Smith T. Local anesthesia affects physiologic parameters and reduces anesthesiologist intervention in children undergoing general anesthesia for dental rehabilitation. Pediatr Dent 2009;31:414-9.

12. Kaufman E, Epstein JB, Gorsky M, Jackson DL, Kadari A. Preemptive analgesia and local anesthesia as a supplement to general anesthesia: A review. Anesth Prog 2005;52:29-38.

13. Moness Ali AM, Hammuda AA. Local anesthesia effects on postoperative pain after pediatric oral rehabilitation under general anesthesia. Pediatr Dent 2019;41:181-5.

14. American Academy of Pediatric Dentistry. Use of local anesthesia for pediatric dental patients. The Reference Manual of Pediatric Dentistry Chicago, IL: American Academy of Pediatric Dentistry 2025:407-14.

15. Malamed SF. Pain management following dental trauma and surgical procedures. Dent Traumatol 2023;39:295-303.

16. Carrasco-Labra A, Polk DE, Urquhart O, Aghaloo T, Claytor JW Jr, Dhar V, *et al*. Evidence-based clinical practice guideline for the pharmacologic management of acute dental pain in adolescents, adults, and older adults: A report from the American Dental Association Science and Research Institute, the University of Pittsburgh, and the University of Pennsylvania. J Am Dent Assoc 2024:155:102-17.

17. British Society of Paediatric Dentistry. Guidelines for the management of children referred for dental extractions under general anaesthesia. London: British Society of Paediatric Dentistry; 2011. Available from: https://www.bspd.co.uk/Professionals/Resources/Clinical-Guidelines-and-Evidence-Reviews. Accessed September 19, 2026.

18. Townsend JA, Martin A, Hagan JL, Needleman H. The use of local anesthesia during dental rehabilitations: A survey of AAPD members. Pediatr Dent 2013;35:422-5.

19. Townsend JA, Hagan JL, Smiley M. Use of local anesthesia during dental rehabilitation with general anesthesia: A survey of dentist anesthesiologists. Anesth Prog 2014;61:11-7.

20. Faghihian R, Golabbakhsh A, Asnaashari E. Professional attitudes and practice of pediatric dentists about the use of local anesthesia for the treatment of children under general anesthesia Anesthesiol Pain Med 2024;14.

21. Turkish Dental Association. Dental Education and Human Resources Report 2024. Available from: https://www.tdb.org.tr/ekler/Dishekimligi_Egitimi_ve_Insangucu-2024.pdf. Accessed 25 June 2025.

22. Almadhoon HW, Abuiriban RW, Almassri H, Al-Hamed FS. Efficacy of 4% articaine buccal infiltration versus inferior alveolar nerve block for mandibular molars with symptomatic irreversible pulpitis: A systematic review and meta-analysis. J Evid Based Dent Pract 2022;222:101712.

23. Aquilanti L, Mascitti M, Togni L, Contaldo M, Rappelli G, Santarelli A. A systematic review on nerve-related adverse effects following mandibular nerve block anesthesia. Int J Environ Res Public Health 2022;19:1627.

24. Sivakumar S, Venkiteswaran A, Roslan MA, Musa S. ssessing modalities used to alleviate postoperative pain in children receiving dental treatment under general anesthesia: A systematic review. J Clin Pediatr Dent 2024;48:15-23.

25. McWilliams PA, Rutherford JS. Assessment of early postoperative pain and hemorrhage in young children undergoing dental extractions under general anesthesia. Int J Paediatr Dent 2007;17:352-7.

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Pediatrik Diş Hekimlerinin Genel Anestezi Altında Lokal Anestezi Kullanımına Yönelik Tercihleri: Kesitsel Bir Çalışma

ÖZET

Amaç: Genel anestezi (GA), dental tedaviyi geleneksel klinik koşullarda tolere edemeyen pediatrik hastalar için yaygın olarak kullanılan bir davranış yönlendirme tekniğidir. Genel anestezi altında gerçekleştirilen dental işlemlerde lokal anestezi (LA) uygulanmasına yönelik standart bir görüş birliği bulunmamaktadır. LA'nin potansiyel faydaları ve risklerine dair çelişkili bulgular, klinik uygulamaları etkilemeye devam etmektedir. Bu çalışma, pedodontistlerin GA altında LA uygulamasına yönelik tercihlerini ve kararlarını etkileyen faktörleri incelemeyi amaçlamıştır.

Gereç ve Yöntemler: Bu çalışma için özel olarak geliştirilen ve geçerlik ile güvenirliği sağlanan 20 maddelik "Pedodontistlerin Lokal Anestezi Tercihleri Anketi (PD-LAPQ)" kullanılmıştır. İçerik ve yüzey geçerliği uzman görüşü ve pilot uygulama ile doğrulanmıştır. Test-tekrar test analiziyle güvenilirlik değerlendirilmiş olup ICC = 0.89 ve Cronbach alfa = 0.80 bulunmuştur. Anket demografik bilgiler, klinik tercihler ve LA kullanımı ya da kullanılmaması nedenlerini içermektedir. Katılımcılar kolayda örnekleme yöntemiyle belirlenmiştir. İstatistiksel analizlerde ki-kare, Mann–Whitney U ve Kruskal–Wallis testleri uygulanmıştır ($p < 0.05$).

Bulgular: Davet edilen 450 diş hekiminden 210'u (%46,7) ankete katılmıştır. Katılımcıların %20'si her zaman LA kullandığını, %1.9'u ise hiç kullanmadığını belirtmiştir; %78.1'i ise duruma göre karar verdiğini ifade etmiştir. Katılımcıların çoğu kadındı (%90.5) ve %70.5'inin beş yıldan fazla klinik deneyimi vardı. Katılımcıların %20'si GA sırasında her zaman LA kullandığını, %1.9'u ise hiç kullanmadığını bildirmiştir. LA kullanımı ile katılımcıların cinsiyeti, klinik deneyimi veya çalıştıkları kurum arasında istatistiksel olarak anlamlı bir ilişki saptanmamıştır.

Sonuç: Bulgular, pedodontistler arasında GA altında LA kullanımına yönelik önemli bir uygulama farklılığı olduğunu ortaya koymuştur. Klinik karar verme süreçlerini geliştirmek ve hasta güvenliğini artırmak için kanıta dayalı standart kılavuzların oluşturulması gerekmektedir.

Anahtar kelimeler: Diş tedavis; Genel anestezi; Lokal anestezi; Pedodonti

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Original Research Article

Effect of Selective Grinding Methods on Fracture Toughness of Monolithic Zirconia with Different Translucency: A FEA Study

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ABSTRACT

Aim: Chairside and laboratory grinding procedures are frequently required to optimize the fit and occlusion of zirconia restorations; however, these adjustments may introduce surface defects, trigger phase transformation, and adversely affect long-term mechanical performance. The influence of clinically relevant grinding parameters on different zirconia generations remains unclear. This study aimed to evaluate the tribomechanical behavior of 3Y-TZP, 4Y-PSZ, and 5Y-PSZ under simulated milling conditions.

Materials and Methods: CAD models of mandibular first molar crowns (1.5 mm thickness) were generated and analyzed using finite element analysis with the Explicit Dynamics module in ANSYS Workbench 2022 R2. A 1.0-mm milling bur was modeled as a rigid body, and rotational speeds ranging from 200000 to 400000 RPM were simulated. Zirconia materials were defined as linear isotropic elastic solids. Wet and dry grinding conditions were represented by friction coefficients of 0.15 and 0.45, respectively. Structural reliability was assessed using Weibull statistics.

Results: Dry milling significantly increased stress magnitudes (820–960 MPa), resulting in fracture probabilities of up to 77% for 5Y-PSZ. Wet milling substantially reduced stresses (520–620 MPa) across all zirconia types. A rotational speed of 350000 RPM minimized vibrational instability.

Conclusion: Wet grinding is critical for preserving the mechanical integrity of high-translucency zirconia. Among the materials tested, 3Y-TZP demonstrated superior fracture toughness under high-stress conditions.

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Keywords: Dental high-speed technique; Dental stress analysis; Finite element analysis; Zirconium oxide

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INTRODUCTION

In recent years, the growing demand for high-aesthetic dental restorations has driven the transition from metal-ceramic to all-ceramic systems.[1, 2] Among these, zirconia-based ceramics have gained prominence due to their favorable biocompatibility, high mechanical strength, and low bacterial adhesion.[3] Particularly, yttria-stabilized tetragonal zirconia polycrystals (Y-TZP) are widely used in fixed prosthodontics as both core and monolithic restorative materials, facilitated by the development of CAD/CAM technologies.[4]

Conventional veneered zirconia restorations often suffer from porcelain chipping at the veneer–core interface, compromising their longevity.[5] Monolithic zirconia restorations were introduced to address this complication by eliminating the veneering layer, thereby enhancing mechanical durability and simplifying clinical procedures.[6] However, mechanical adjustments, such as grinding and polishing during clinical or laboratory adaptation, can induce surface defects, trigger tetragonal-to-monoclinic phase transformation, and reduce the long-term strength of zirconia.[7, 8]

The optical and mechanical properties of zirconia have been further optimized through the development of new generations of zirconia with varying yttria content, such as 3Y-TZP, 4Y-PSZ, and 5Y-PSZ.[9] These materials differ in their translucency and fracture toughness, influencing their clinical indications.[9,10] Understanding how surface modification parameters such as rotational speed, and the presence of coolant, affect the mechanical performance of these zirconia materials is crucial for optimizing restorative outcomes.[7, 8]

This study aims to evaluate the mechanical response of different generations of monolithic zirconia (3Y-TZP, 4Y-PSZ, and 5Y-PSZ) under various clinical grinding conditions using finite element analysis (FEA), focusing on the effects of coolant application (wet vs. dry conditions), rotational speed (rpm) and zirconia translucency level. It was hypothesized that 3Y-TZP would exhibit greater fracture toughness to grinding-induced stress and fracture compared to 4Y-PSZ and 5Y-PSZ due to its higher tetragonal phase stability, that wet grinding conditions would result in more favorable stress distribution and higher fracture toughness than dry conditions by reducing frictional heat accumulation and minimizing thermally induced microstructural damage, and that increasing rotational speed would lead to greater stress concentration within the zirconia structure. The findings are expected to provide insights into optimal clinical adjustment protocols that minimize stress concentration and preserve the structural integrity of zirconia restorations.

MATERIALS AND METHODS

This study was conducted to evaluate the mechanical stress response of monolithic zirconia ceramics during high-speed milling using the Explicit Dynamics module within the ANSYS WorkBench 2022 R2 (ANSYS Inc., Canonsburg, PA, USA) Finite Element Analysis (FEA) platform. Three-dimensional (3D) crown models, specifically a simplified geometry representing the mandibular first molar and maintaining a block thickness of 1.5 mm, were generated using CATIA V5 (Dassault Systèmes, Vélizy-Villacoublay, France) software. This simplification focused the analysis on the zirconia material's mechanical reaction while maintaining computational efficiency (Fig.1A-B).

Three distinct zirconia materials from the same manufacturer were selected based on their varying translucency levels: KATANA Zirconia HTML (3Y-TZP), STML (4Y-PSZ), and UTML (5Y-PSZ) (Kuraray Noritake, Tokyo, Japan). A single 1.0 mm diameter bur geometry was employed in the simulation (Fig.2). To streamline calculations and maintain focus on the stress distribution within the zirconia, the milling bur was idealized as a Rigid Body, neglecting the bur's material-specific deformation. However, four distinct rotational speeds, representative of common clinical practice with dental micromotors and high-speed air turbines, were defined: 200000 RPM, 300000 RPM, 350000 RPM, and 400000 RPM.

Zirconia, being a brittle material, exhibits a linear elastic response until the point of fracture. Accordingly, the material behavior was defined using the

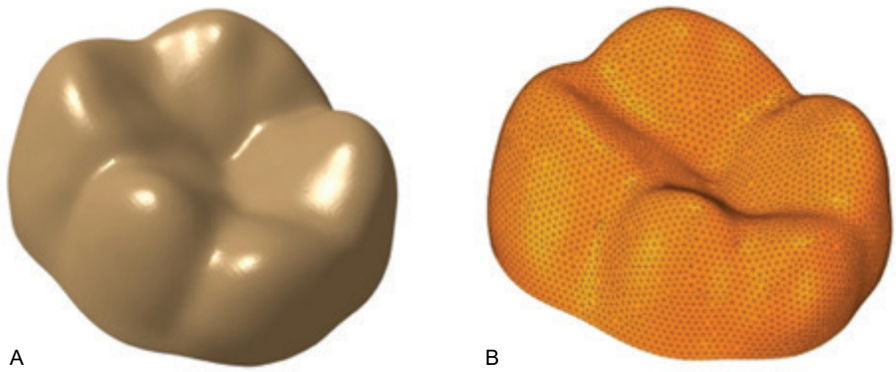


Figure 1. Mandibular first molar; A, crown model. B, mesh image.

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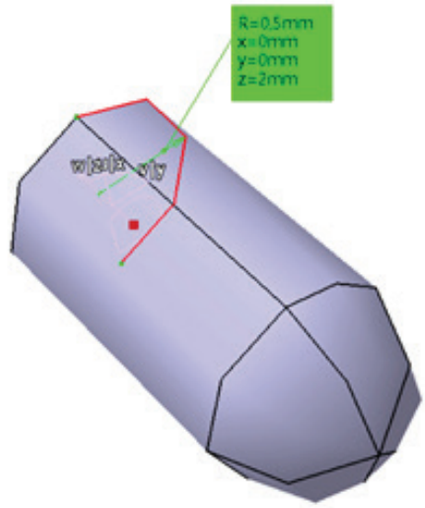


Figure 2. 1.0 mm radius chamfer bur point CAD model

Linear Isotropic Elastic Model based on Hooke's Law principles, requiring the definition of Elastic Modulus, Poisson's Ratio, and Density. Since the fracture behavior of brittle materials is governed by a stochastic process dependent on the size and distribution of critical flaws within the material volume, rather than a deterministic strength threshold, the structural reliability and probability of failure (PoF) of the zirconia specimens were characterized using a two-parameter Weibull distribution function based on the weakest link principle. This model is defined by two parameters: the characteristic strength, representing the stress level at which specimen failure is expected, and the unitless Weibull Modulus, which reflects the scatter of strength data and thus the homogeneity of the flaw population within the material. Accordingly, rather than relying on a single peak stress value, the stress values and corresponding volumes of all elements within the finite element mesh were individually considered, and the cumulative probability of fracture was calculated for each specimen using Weibull statistics This statistical approach allowed for the calculation of cumulative fracture probability across the finite element mesh, rather than relying solely on a deterministic maximum stress value. Material properties were defined according to the manufacturer's data and previous report (Table 1).[11]

The mechanical effects of the clinical environment were incorporated by simulating wet and dry milling conditions. These conditions were modeled through the variation of the Coefficient of Friction (COF), independent of thermal analysis:

Wet Milling: A COF of μ=0.15 was adopted, representing the lubricating and chip-evacuating effect of the coolant, which minimizes direct contact and friction.

Dry Milling: A higher COF of μ=0.45 was utilized, reflecting the aggressive dry-sliding mechanisms and increased friction resistance observed at the tool-material interface in the absence of coolant.

The use of the Explicit Dynamics solver was chosen for its solution stability and precise time-step management, which is critical for accurately modeling high-velocity, short-duration impact, and complex contact interactions inherent in high-speed milling.

Table 1. Parameters for Zirconia Blocks[11]

Category	Properties	3Y-TZP	4Y-PSZ	5Y-PSZ	Unit
Density	Density	6080	6060	6050	kg/m³
Elastic	Young's Modulus	2.1e+05	2.05e+05	2.00e+05	MPa
	Poisson's Ratio	0.300	0.310	0.320	-
	Bulk Modulus	1.75e+05	1.79e+05	1.85e+05	MPa
	Shear Modulus	80769	78244	75757	MPa
Weibull	Characteristic Strenght	837.41	415.37	318.50	MPa
	Weibull Modulus	8.96	6.03	5.76	-

kg/m³: Kilograms per Cubic Meter
MPa: Megapascal

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RESULTS

The Explicit Dynamics analysis demonstrated a critical and complex interaction between material properties, tribological conditions, and rotational speed on the mechanical response of monolithic zirconia ceramics. Quantitatively, the simulations confirmed the generation of extremely high maximum contact stresses, peaking at 960 MPa on the zirconia surface. These peak stress magnitudes and the resultant probability of failure (PoF) were overwhelmingly governed by the milling environment (Fig. 3, Fig. 4).

Across all simulated conditions, maximum contact stress values ranged from 526.6 MPa (lowest, recorded under wet milling at 300,000 RPM) to 963.7 MPa (highest, recorded under dry milling at 300,000 RPM), while the corresponding probability of failure ranged from as low as 0.00% (3Y-TZP under wet conditions) to as high as 77.28% (5Y-PSZ under dry conditions at 200,000 RPM)

The study established a critical non-linear relationship between Rotational Speed (RPM) and mechanical risk, particularly evident in dry milling scenarios.

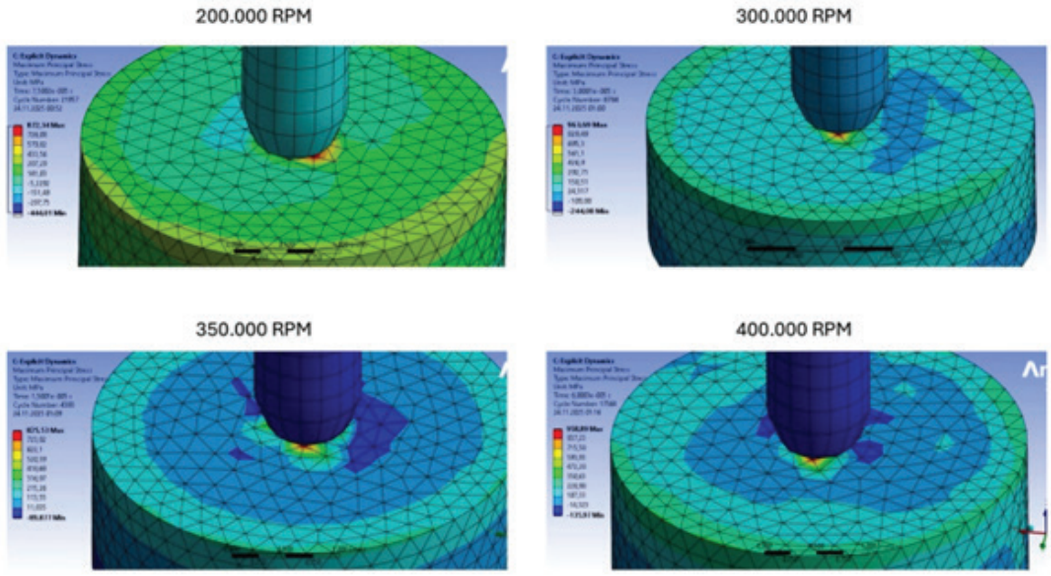


Figure 3. Maximum principal stress analysis at 200.000 RPM, 300.000 RPM, 350.000 RPM and 400.000 RPM in dry conditions

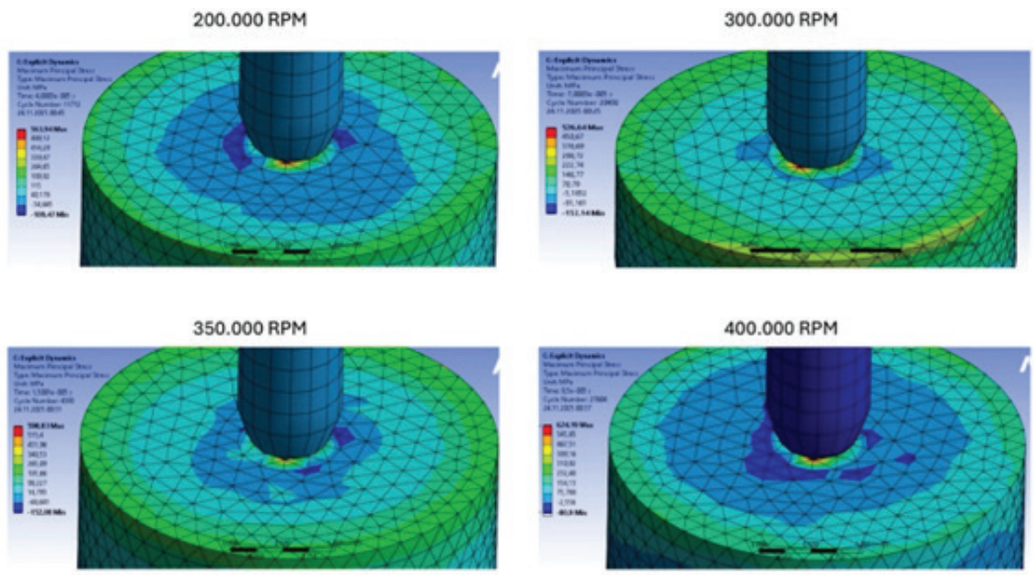


Figure 4. Maximum principal stress analysis at 200.000 RPM, 300.000 RPM, 350.000 RPM and 400.000 RPM in wet conditions

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Low speeds of 200000 RPM induced high risk (77.28% PoF with 872 MPa stress) because the insufficient cutting velocity favored an inefficient dragging/tearing mechanism over clean cutting. Conversely, high speeds like 400000 RPM also led to high risk (70.54% PoF with 958 MPa stress) due to the amplification of inertial and impact forces. Crucially, 350000 RPM was identified as the Optimum Safe Point (lowest risk at 47.48% PoF with 825 MPa stress), where cutting dynamics were stabilized; this behavior is attributed to operating within a favorable stability lobe where vibrations and energy expenditure are minimized.

Furthermore, wet milling, defined by a lower coefficient of Friction (μ=0.15), effectively mitigated risk by confining the maximum stresses to a manageable range of 520–620 MPa; this coolant effect kept the PoF for the structurally sensitive 5Y-PSZ material within an acceptable 9%–15% range. Conversely, dry milling, characterized by increased friction, dramatically escalated the stress levels to between 820 MPa and 960 MPa. This rapid escalation in mechanical loading resulted in a catastrophic PoF surge up to 77% for 5Y-PSZ, confirming that the absence of lubrication and cooling constitutes a critical failure risk for high-translucency zirconias. Concurrently, the material hierarchy remained consistent across conditions, with the high-toughness 3Y-TZP maintaining integrity (PoF < 1%), while the lower-rigidity 5Y-PSZ proved most vulnerable (Table 2, Table 3).

Table 2. Weibull analysis for dry conditions

Speed	Material	Maximum Simulation Stress	m	Sigma0	R0 (risk)	PoF (%)
200.000 RPM	5Y-PSZ	872.34 MPa	5.76	318.50	1.4818	77.28%
	4Y-PSZ	872.34 MPa	6.03	415.37	0.3526	29.72%
	3Y-TZP	872.34 MPa	8.96	837.41	0.0034	0.34%
300.000 RPM	5Y-PSZ	963.69 MPa	5.76	318.50	1.1339	67.82%
	4Y-PSZ	963.69 MPa	6.03	415.37	0.3038	26.20%
	3Y-TZP	963.69 MPa	8.96	837.41	0.0065	0.65%
350.000 RPM	5Y-PSZ	825.53 MPa	5.76	318.50	0.6440	47.48%
	4Y-PSZ	825.53 MPa	6.03	415.37	0.1613	14.89%
	3Y-TZP	825.53 MPa	8.96	837.41	0.0019	0.18%
400.000 RPM	5Y-PSZ	958.89 MPa	5.76	318.50	1.2223	70.54%
	4Y-PSZ	958.89 MPa	6.03	415.37	0.3186	27.28%
	3Y-TZP	958.89 MPa	8.96	837.41	0.0062	0.62%

3Y-TZP: 3 mol% Yttria-Stabilized Tetragonal Zirconia Polycrystal, 4Y-PSZ: 4 mol% Yttria-Partially Stabilized Zirconia,
5Y-PSZ: 5 mol% Yttria-Partially Stabilized Zirconia, RPM: Revolutions Per Minute, m: Weibull Modulus, Sigma0: Characteristic Strength
R0: Risk of Rupture, PoF: Probability of Failure, MPa: Megapascal

Table 3. Weibull analysis for wet conditions

Speed	Material	Maximum Simulation Stress	m	Sigma0	R0 (risk)	PoF (%)
200.000 RPM	5Y-PSZ	563.94 MPa	5.76	318.50	0.0967	9.22%
	4Y-PSZ	563.94 MPa	6.03	415.37	0.0203	2.01%
	3Y-TZP	563.94 MPa	8.96	837.41	0.0001	0.01%
300.000 RPM	5Y-PSZ	526.64 MPa	5.76	318.50	0.1476	13.72%
	4Y-PSZ	526.64 MPa	6.03	415.37	0.0299	2.94%
	3Y-TZP	526.64 MPa	8.96	837.41	0.0000	0.00%
350.000 RPM	5Y-PSZ	598.83 MPa	5.76	318.50	0.1629	15.03%
	4Y-PSZ	598.83 MPa	6.03	415.37	0.0348	3.42%
	3Y-TZP	598.83 MPa	8.96	837.41	0.0001	0.01%
400.000 RPM	5Y-PSZ	624.19 MPa	5.76	318.50	0.1429	13.32%
	4Y-PSZ	624.19 MPa	6.03	415.37	0.0315	3.10%
	3Y-TZP	624.19 MPa	8.96	837.41	0.0001	0.01%

3Y-TZP: 3 mol% Yttria-Stabilized Tetragonal Zirconia Polycrystal, 4Y-PSZ: 4 mol% Yttria-Partially Stabilized Zirconia
5Y-PSZ: 5 mol% Yttria-Partially Stabilized Zirconia, RPM: Revolutions Per Minute, m: Weibull Modulus, Sigma0: Characteristic Strength
R0: Risk of Rupture, PoF: Probability of Failure, MPa: Megapascal

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DISCUSSION

The mechanical performance of monolithic zirconia restorations is strongly influenced by chairside adjustments performed with rotary instruments. Numerous studies have demonstrated that grinding parameters such as rotational speed (rpm), coolant application, and zirconia translucency affect surface integrity, phase stability, and ultimately the long-term strength of the material.[12-16]

Previous research consistently showed that grinding procedures reduce the flexural strength of zirconia compared with unaltered controls, although the extent of reduction varies.[13-15] Several authors reported that high-speed handpieces combined with short grinding times tend to preserve strength better than low-speed continuous grinding, which often generates more heat and surface defects.[13,14,16] Increased temperature during dry grinding has been associated with enhanced tetragonal to monoclinic (t→m) transformation, microcrack formation, and deterioration of mechanical properties.[15,17] Conversely, short-term high-speed grinding with adequate coolant was found to mitigate these adverse effects.[18,22]

In the present study, analyses revealed a complex, non-linear relationship between rotational speed (RPM), stress levels, and the probability of fracture (PoF) in zirconia. Specifically, under dry conditions, the “slower is safer” hypothesis was refuted: relatively low speeds (200000 RPM) induced high risk (77.28% PoF at 872 MPa) due to a dominant dragging/tearing mechanism caused by insufficient cutting velocity. Conversely, excessively high speeds (400000 RPM) also elevated risk (70.54% PoF at 958 MPa) due to increased centrifugal forces and impact energy.

Crucially, 350000 RPM was identified as the optimum safe point (lowest risk: 47.48% PoF at 825 MPa), where resonant vibrations were minimized and cutting efficiency was maximized. This performance is explained by the material-tool dynamic operating within a favorable stability lobe, enabling the absorption of 30%–40% of the mechanical load imposed by dry cutting. Consequently, to mitigate subsurface damage in brittle zirconia, milling strategies should target this optimum RPM band (approximately 350000 RPM).

The role of coolant application remains complex. While many studies emphasize that water cooling limits temperature rise and reduces microcrack formation,[18, 19] others reported no significant advantage or even reduced strength under wet conditions, particularly when tungsten carbide burs were used.[20] This inconsistency suggests that both thermal and mechanical damage mechanisms must be considered, and the outcome likely depends on the grinding protocol.

Consistent with these reports, findings conclusively demonstrate that tribological conditions are the most critical factor governing the mechanical integrity of the material during milling. Under wet conditions, the low coefficient of friction significantly limited maximum stresses to the 520–620 MPa range, maintaining the fracture risk for even the susceptible 5Y-PSZ material within a manageable 9%–15% range. This result confirms that the coolant acts as both a lubricant and a thermal moderator, dramatically reducing the risk of critical subsurface damage during abrasion. In contrast, analyses of dry conditions showed that increased friction instantaneously elevated stresses to 820–960 MPa. This surge in stress, exacerbated by the effect of heat on material strength, drove the fracture risk in 5Y-PSZ to an unacceptable 70%–77% range. Consequently, the simulation results strongly support the engineering necessity of wet milling for low-rigidity zirconia materials like 5Y-PSZ, as dry processing constitutes a risk factor for catastrophic failure.

Material composition also determines the response to grinding. Comparative studies on zirconia with varying yttria content and translucency (3Y-TZP, 4Y-PSZ, 5Y-PSZ) demonstrated that higher-translucency materials, rich in cubic phase, generally exhibit lower fracture toughness and are less prone to t→m transformation during grinding.[21, 23, 24] In contrast, conventional 3Y-TZP is mechanically more robust but more sensitive to surface damage. These findings underline the need to tailor adjustment protocols to the specific zirconia generation used.[21, 23]

The present analyses confirmed this mechanical hierarchy, showing that 3Y-TZP exhibited the highest rigidity and stress levels, while 5Y-PSZ—characterized by higher translucency and lower elastic modulus—showed significantly greater total deformation,

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especially under dry conditions. These findings align with existing literature,demonstrating that increasing translucency enhances optical properties at the cost of mechanical strength and stability.[23, 24]

Overall, the literature suggests that minimizing grinding time and using high-speed handpieces with adequate coolant may help maintain the mechanical integrity of zirconia restorations.[13-16, 21, 23-25] Nonetheless, results vary across studies due to differences in experimental setups, test methods, and material compositions, indicating the importance of further standardized investigations.

The present study contributes to this body of evidence by quantitatively demonstrating, through finite element analysis, that higher rotational speeds and coolant use collectively minimize stress accumulation and deformation in zirconia. These parameters are therefore recommended for achieving safer, more controlled chairside adjustments, particularly for highly translucent generations of zirconia.

CONCLUSIONS

Based on the outcomes of this *in vitro* investigation, wet milling emerges as a non-negotiable parameter for the safe processing of zirconia, effectively maintaining stress levels within the acceptable 520–620 MPa range. In contrast, dry milling substantially increases internal stresses (reaching up to 960 Mpa) and consequently yields an intolerable fracture probability of 77% in 5Y-PSZ. The findings further substantiate that increasing translucency is associated with diminished structural resilience; thus, the mechanically inferior 5Y-PSZ exhibits pronounced vulnerability to machining-induced damage, whereas 3Y-TZP and 4Y-PSZ remain more suitable for clinical scenarios requiring superior damage tolerance. Moreover, the commonly held assumption that reduced rotational speed enhances safety is refuted; instead, an optimized operational speed of 350000 RPM was identified as the critical threshold that mitigates resonant vibrational effects while preserving cutting efficiency. Collectively, these findings underscore the imperative of integrating wet milling, judicious material selection, and optimized RPM into clinical and laboratory protocols to ensure the mechanical longevity of zirconia restorations.

CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare.

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During the preparation of this work the authors used ChatGPT (OpenAI) and Gemini (Google One) to assist in the revision of grammar, structure, and language clarity during the manuscript preparation, the AI tool was not used for generating original scientific content, data interpretation, or conclusions. The authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

REFERENCES

1. Silva NR, Sailer I, Zhang Y, Coelho PG, Guess PC, Zembic A, *et al.* Performance of zirconia for dental healthcare. Materials 2010;3:863–96.

2. Tholt de Vasconcellos B, Miranda-Júnior WG, Prioli R, Thompson J, Oda M. Surface roughness in ceramics with different finishing techniques using atomic force microscope and profilometer. Oper Dent 2006;31:442–9.

3. Raigrodski AJ. Contemporary all-ceramic fixed partial dentures: a review. Dent Clin North Am 2004;48:531–44.

4. Triwatana P, Nagaviroj N, Tulapornchai C. Clinical performance and failures of zirconia-based fixed partial dentures: a review literature. J Adv Prosthodont 2012;4:76–83.

5. Kimmich M, Stappert CF. Intraoral treatment of veneering porcelain chipping of fixed dental restorations: A review and clinical application. J Am Dent Assoc 2013;144:31-44.

6. Vagkopoulou T, Koutayas SO, Koidis P, Strub JR. Zirconia in dentistry: Part 1. Discovering the nature of an upcoming bioceramic. Eur J Esthet Dent 2009;4:130–51.

7. Huh YH, Park CJ, Cho LR. Evaluation of various polishing systems and the phase transformation of monolithic zirconia. J Prosthet Dent 2016;116:440–9.

8. Canneto JJ, Cattani-Lorente M, Durual S, Wiskott AH, Scherrer SS. Grinding damage assessment on four high-strength ceramics. Dent Mater 2016;32:171–82.

9. Stawarczyk B, Keul C, Eichberger M, Figge D, Edelhoff D, Lümkemann N. Three generations of zirconia: From veneered to monolithic. Part I. Quintessence Int 2017;48:369-80.

10. Güth JF, Stawarczyk B, Edelhoff D, Liebermann A. Zirconia and its novel compositions: What do clinicians need to know? Quintessence Int 2019;50:512–20.

11. Bruhnke M, Awwad Y, Müller WD, Beuer F, Schmidt F. Mechanical properties of new generations of monolithic, multilayered zirconia. Materials 2022;16:276.

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12. Kosmač T, Oblak C, Jevnikar P, Funduk N, Marion L. The effect of surface grinding and sandblasting on flexural strength and reliability of Y-TZP zirconia ceramic. Dent Mater 1999;15:426–33.

13. İşeri U, Özkurt Z, Yalnız A, Kazazoğlu E. Comparison of different grinding procedures on the flexural strength of zirconia. J Prosthet Dent 2012;107:309–15.

14. İşeri U, Özkurt Z, Kazazoğlu E, Küçükoğlu D. Influence of grinding procedures on the flexural strength of zirconia ceramics. Braz Dent J 2010;21:528–32.

15. Kosmač T, Dakskobler A, Oblak Č, Jevnikar P. The strength and hydrothermal stability of Y-TZP ceramics for dental applications. Int J Appl Ceram Technol 2007;4:164–74.

16. Hetou S. Comparison of cutting efficiency of different rotary instruments on two different ceramic materials using electric and air-turbine dental handpieces [thesis]. Fort Lauderdale: Nova Southeastern University; 2018.

17. Hatanaka GR, Polli GS, Fais LM, Reis JMdSN, Pinelli LA. Zirconia changes after grinding and regeneration firing. J Prosthet Dent 2017;118:61–8.

18. Hjerppe J, Närhi TO, Vallittu PK, Lassila LV. Surface roughness and the flexural and bend strength of zirconia after different surface treatments. J Prosthet Dent 2016;116:577–83.

19. Pereira G, Amaral M, Simoneti R, Rocha G, Cesar P, Valandro L. Effect of grinding with diamond-disc and -bur on the mechanical behavior of a Y-TZP ceramic. J Mech Behav Biomed Mater 2014;37:133–40.

20. Ho C, Ding H, Chen X, Tsoi J, Botelho M. The effects of dry and wet grinding on the strength of dental zirconia. Ceram Int 2018;44:10451–62.

21. Abdulmajeed A, Sulaiman TA, Abdulmajeed AA, Närhi TO. Strength and phase transformation of different zirconia types after chairside adjustment. J Prosthet Dent 2024;132:455–63.

22. Lee KR, Choe HC, Heo YR, Lee JJ, Son MK. Effect of different grinding burs on the physical properties of zirconia. J Adv Prosthodont 2016;8:137–45.

23. Abdulmajeed A, Sulaiman T, Abdulmajeed A, Bencharit S, Närhi T. Fracture load of different zirconia types: a mastication simulation study. J Prosthodont 2020;29:787–91.

24. Pereira GK, Guilardi LF, Dapieve KS, Kleverlaan CJ, Rippe MP, Valandro LF. Mechanical reliability, fatigue strength and survival analysis of new polycrystalline translucent zirconia ceramics for monolithic restorations. J Mech Behav Biomed Mater 2018;85:57–65.

25. Ramos GF, Pereira GKR, Amaral M, Valandro LF, Bottino MA. Effect of grinding and heat treatment on the mechanical behavior of zirconia ceramic. Braz Oral Res 2016;30.

Farklı Translusensiye Sahip Monolitik Zirkonya Seramiklerin Kırılma Direnci Üzerine Farklı Selektif Aşındırma Yöntemlerinin Etkisi: Bir SEA Çalışması

ÖZET

Amaç: Zirkonyum restorasyonların uyum ve oklüzyonunu optimize etmek için klinik ve laboratuvar aşındırma işlemleri sıklıkla gerekmektedir; ancak bu düzeltmeler yüzey defektlerine yol açabilir, faz dönüşümünü tetikleyebilir ve uzun vadeli mekanik performansı olumsuz etkileyebilir. Klinik açıdan ilgili aşındırma parametrelerinin farklı zirkonyum nesilleri üzerindeki etkisi henüz netlik kazanmamıştır. Bu çalışma, simüle edilmiş frezeleme koşulları altında 3Y-TZP, 4Y-PSZ ve 5Y-PSZ'nin tribomekanik davranışını değerlendirmeyi amaçlamaktadır.

Gereç ve Yöntemler: Alt birinci molar kronlarının (1.5 mm kalınlık) CAD modelleri oluşturuldu ve ANSYS Workbench 2022 R2'deki Açık Dinamik modülü ile sonlu elemanlar analizi kullanılarak incelendi. 1.0 mm'lik frezeleme frezesi rijit cisim olarak modellenip; 200000 ile 400000 RPM arasında değişen dönüş hızları simüle edildi. Zirkonyum malzemeler lineer izotropik elastik katılar olarak tanımlandı. Sulu ve susuz aşındırma koşulları sırasıyla 0.15 ve 0.45 sürtünme katsayılarıyla temsil edildi. Yapısal güvenilirlik Weibull istatistikleri kullanılarak değerlendirildi.

Bulgular: Susuz frezeleme, gerilme büyüklüklerini belirgin biçimde artırdı (820–960 MPa) ve 5Y-PSZ için %77'ye varan kırılma olasılıklarına neden oldu. Sulu frezeleme tüm zirkonyum türlerinde gerilimleri önemli ölçüde azalttı (520–620 MPa). 350000 RPM dönüş hızının titreşim kararsızlığını en aza indirdiği belirlendi.

Sonuç: Sulu aşındırma, yüksek translusensili zirkonyumun mekanik bütünlüğünün korunması için kritik öneme sahiptir. Test edilen malzemeler arasında 3Y-TZP, yüksek gerilme koşullarında üstün direnç sergilemiştir.

Anahtar Kelimeler: Dental stres analizi; Dental yüksek devirli teknik; Sınırlı eleman analiz; Zirkonyum oksit

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Original Research Article

Evaluation of Dental Students' Knowledge and Competence in Diagnosing Periodontal Disease: A Cross-Sectional Survey Study

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ABSTRACT

Aim: This study aimed to evaluate the knowledge levels of 3rd, 4th, and 5th-year students regarding the diagnosis of periodontal disease.

Materials and Methods: In this cross-sectional survey study, a 25-item questionnaire was administered covering the identification and classification of periodontal diseases, clinical evaluation, confidence in the diagnosis–treatment process, application of clinical scales, access to resources, and desire for specialization. Descriptive statistics (frequency and percentage) were used to summarize the data. All statistical analyses were performed using the R software (version 4.5.1). Ordinal trends across Year 3, Year 4, and Year 5 were assessed using the Jonckheere-Terpstra test, with Kendall's tau as the effect size. To account for multiple comparisons, the Benjamini–Hochberg false discovery rate (FDR) correction was applied. Multiple-choice items were evaluated using the multiple Chi-squared test. Statistical significance was set at $p < 0.05$.

Results: Ordinal trend analysis (Jonckheere-Terpstra) demonstrated significant increases in Likert scores across academic years for 13 of 24 items after FDR correction ($P < 0.05$) with generally small effect sizes (Kendall's $\tau = 0.13$ to 0.25), the consistent upward trend indicates progressively greater agreement among senior students. Reported diagnostic challenges also varied by year, with lack of theoretical knowledge decreasing notably in the 4th year (48.1% in year 3 vs. 22% in year 4) and concern about misdiagnosis being lowest among 5th-year students (19.8%), suggesting increasing competency with advancing training.

Conclusion: The upward trend observed across academic years likely reflects increasing familiarity with the subject matter and greater clinical exposure among senior students. These findings suggest that the perceptions assessed by the survey progressively strengthen throughout the later stages of the curriculum, indicating a gradual development of knowledge level and confidence in periodontal evaluation.

Keywords: Cross-Sectional studies; Dental; Nonparametric statistics; Periodontal diseases; Periodontal diagnosis; Students

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INTRODUCTION

Periodontal disease is a chronic inflammatory, multifactorial disease characterized by damage to the teeth and supporting tissues, affecting oral and systemic health.[1] As with other chronic conditions, tissue destruction in periodontal disease progresses through active and passive phases. However, the severity of the disease can vary between individuals. Tissue destruction can even occur at different levels in different areas of the same individual's mouth.[2, 3]

Regular dental check-ups are particularly important for the early diagnosis, treatment, and management of periodontal diseases. This is because individuals often only realize they have periodontal disease in its advanced stages.[4] Studies have shown that general dentists may not be able to correctly diagnose periodontal diseases and that the possibility of not referring patients to the necessary specialist care in time may limit the effectiveness of the treatment interventions applied.[5-7]

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Students who are the future general dentists also take on the responsibility of meeting these expectations upon completing their education. However, there are only a limited number of studies in the existing literature on students' level of preparedness for periodontal care and the difficulties they encounter in the periodontal diagnosis and treatment process.[8-10] Studies show that dental students have more difficulty diagnosing the disease than treating it.[9, 11]

Assessing students' knowledge, confidence, attitudes, and skills in the periodontal field is critical for determining the objectives of interventions aimed at improving periodontology education. In particular, the limited number of studies conducted in the areas of periodontal treatment planning and patient referral highlights the need for more comprehensive evidence on the subject. [8, 9]

Students' views on the challenges they encounter during periodontal education can contribute to determining the goals of corrective interventions in periodontal education. A recent study evaluated students' knowledge, confidence, skills, and self-reported difficulties regarding periodontal education. It concluded that students' knowledge of diagnosis and treatment planning was acceptable, but that further improvements in periodontal education were necessary to address deficiencies in fundamental areas.[10]

The aim of this study was to evaluate the diagnostic challenges and knowledge level of 3rd-, 4th-, and 5th-year dental students in identifying periodontal diseases, with a particular focus on detecting potential monotonic trends across academic years. By examining these patterns, the study aims to provide evidence-based insight into the effectiveness of the current educational process and identify areas for improvement in periodontal training.

MATERIALS AND METHODS

This cross-sectional questionnaire-based study included 276 third-, fourth-, and fifth-year students enrolled at the Faculty of Dentistry, Bolu Abant İzzet Baysal University (BAİBÜ), during the 2025-2026 academic year. A non-random convenience sampling approach was employed, and all eligible students were invited to participate in the survey. Participation was voluntary, and informed consent was obtained from all individuals who agreed to participate.

The study protocol was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Bolu Abant İzzet Baysal University Non-Interventional Clinical Research Ethics Committee (No: 2025/457). Written informed consent was obtained from all participants prior to the commencement of the study. First- and second-year students were excluded because they had not yet received clinical periodontal training. Incomplete or incorrectly completed questionnaires were also excluded from the analysis.

Sample size estimation was performed using G*Power software (version 3.1.9.2). [12] Assuming an alpha level of 0.05, a statistical power of 95%, and a medium effect size (Cohen's w = 0.30, df = 8) according to Cohen [13], the minimum required sample size was determined to be 253 participants.

A structured questionnaire consisting of 25 items was used for data collection in this study. All items were evaluated using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The content validity of the questionnaire was assessed using the Lawshe method. Five subject-matter experts evaluated each item as "essential," "useful but not essential," or "not necessary." The Content Validity Ratio (CVR) was calculated for each item. For a panel of five experts, the minimum acceptable CVR value was set at 0.99. Reliability was assessed using a test–retest procedure. Agreement between repeated measurements was evaluated using Cohen's Kappa statistics (Two-Way Mixed, Consistency), and all Kappa coefficients exceeded 0.610, demonstrating statistically significant agreement and satisfactory reliability ($p < 0.05$).

After explaining the purpose and method of the study to the individuals, consent was obtained from those who agreed to participate, and they were asked to complete the survey form. The questionnaire form inquired about the individuals' demographic data (age, gender, grade), general and subject-related theoretical knowledge, clinical practice and skills, self-assessments related to the subject, clinical practice skills and resource adequacy related to the subject, difficulties they experienced in diagnosing periodontal disease, and their desire to specialize in the periodontal field.

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Statistical Analysis

Survey responses were analyzed using R (version 4.5.1). The 24 items were measured on a five-point Likert scale (1 = strongly disagree to 5 = strongly agree), with missing responses excluded. Descriptive statistics (mean, SD, median, IQR) were calculated by academic year (years 3 to 5). Multiple-choice items were analyzed using the multiple Chi-squared test. Due to being more informative to show the trends across academic training years, the mean values were used in the results section and the tables rather than the median values despite using a non-parametric analysis.

Ordinal trends across years were assessed with the non-parametric Jonckheere-Terpstra test, with Kendall's tau (τ) as the effect size (τ < 0.10 = negligible, 0.10 to 0.29 = small, 0.30 to 0.49 = moderate, ≥ 0.50 = large). Benjamini–Hochberg false-discovery rate (FDR) correction was applied for multiple comparisons. Statistical significance was set at $p < 0.05$.

RESULT

Descriptive statistics for participants' demographic characteristics are presented in Table 1. An examination of participants' demographic characteristics revealed that 65.2% were female (n=180) and 34.8% were male (n=96). Looking at the class distribution, 37% of the participants were in the third grade (n=102), 37% were in the fourth grade (n=102), and 26.1% were in the fifth grade (n=72). The participants' ages ranged from 20 to 34, with a mean age of 23±1.5.

The descriptive statistics of the questionnaire items are presented in Table 2. Overall, the mean scores of the items ranged from 3.24 to 4.21, indicating a moderate-to-high level of self-perceived knowledge and confidence regarding periodontal disease diagnosis and management. The highest mean score was observed for the ability to explain the relationship between periodontal disease and oral hygiene (4.25), whereas the lowest mean score was observed for the desire to specialize in the early diagnosis of periodontal diseases (3.24).

Table 1. Distribution according to individuals' demographic characteristics

		n	%
Gender	Female	180	65.2
	Male	96	34.8
Class	3rd grade	102	37.0
	4th grade	102	37.0
	5th grade	72	26.1
	Min-Max	Median±SD	
Age	20-34	23±1.5	

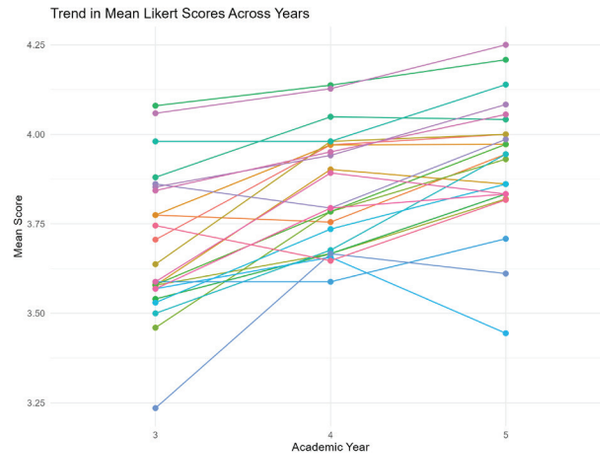


Figure 1. Distribution of correct responses to statistically significant questions according to students' academic year.

In our study, questions 1, 7, 8, 12, 13, 15, 16, 17, 20, 21, and 24 showed statistically significant year-based differences among the classes (Table 3). As shown in Figure 1, these items demonstrated a clear upward trend across the third-, fourth-, and fifth-year students. These findings indicate a measurable progression in periodontal knowledge and clinical awareness throughout the educational years.

Students' self-reported theoretical knowledge regarding the diagnosis of periodontal diseases increased across academic years, with mean Likert scores rising from 3.70 in Year 3 to 3.97 in Year 4 and 4.00 in Year 5. This upward trend was statistically significant after FDR correction ($p = 0.002$, FDR-adjusted p (P_FDR) = 0.01), indicating progressively greater confidence in theoretical understanding among senior students.

Analysis of survey responses across years 3, 4, and 5 demonstrated significant improvements in several aspects of students' theoretical knowledge, clinical knowledge level, and diagnostic confidence in periodontal diseases. After FDR correction (P_FDR < 0.05), significant upward trends were observed for the following items:

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Table 2. Descriptive Statistical Analysis of Likert-Scale Responses

Question	Year	N	Median	IQR	Mean±SD
I Have Sufficient Theoretical Knowledge Regarding The Diagnosis Of Periodontal Diseases.	3	102	4	1	3.70±0.60
	4	102	4	0	3.97±0.51
	5	72	4	0	4.00±0.69
I Can Identify The Risk Factors For Periodontal Diseases.	3	102	4	0	3.98±0.6
	4	102	4	0	3.98±0.49
	5	72	4	0	4.14±0.54
I Can Explain The Effect Of Systemic Disease Findings On The Diagnosis Of Periodontal Disease.	3	101	4	0	3.86±0.60
	4	102	4	0	3.79±0.57
	5	72	4	0	3.99±0.62
I am Knowledgeable About The Prevention And Treatment Of Periodontal Diseases.	3	102	4	0	3.85±0.60
	4	102	4	0	3.94±0.48
	5	72	4	0	4.08±0.52
I Can Explain The Risk Of Smoking İn Relation To Periodontal Disease.	3	102	4	0	4.06±0.73
	4	102	4	0	4.13±0.50
	5	72	4	1	4.25±0.50
I Can Establish A Relationship Between Periodontal And Systemic Diseases.	3	102	4	0	3.84±0.65
	4	102	4	0	3.95±0.51
	5	72	4	0	4.06±0.50
I Can Correctly Classify Periodontal Diseases	3	102	4	1	3.59±0.75
	4	102	4	0	3.89±0.54
	5	72	4	0	3.83±0.71
I Am Competent In Assessing The Severity Of Periodontal Diseases.	3	102	4	1	3.57±0.74
	4	102	4	1	3.79±0.57
	5	72	4	0.25	3.83±0.67
I Can Accurately Determine Attachment Loss İn Periodontal Diseases.	3	102	4	1	3.74±0.81
	4	102	4	1	3.65±0.67
	5	71	4	0.5	3.817±0.78
I Can Accurately Determine Radiographic Bone Loss İn Periodontal Diseases.	3	102	4	1	3.77±0.72
	4	102	4	1	3.75±0.64
	5	72	4	0	3.94±0.60
I Can Use The İnstruments Required For Diagnosing Periodontal Disease Correctly And Effectively.	3	102	4	1	3.77±0.81
	4	102	4	0	3.97±0.59
	5	72	4	0	3.97±0.75
I Can Follow A Systematic Approach When Evaluating Periodontal Diseases.	3	102	4	1	3.58±0.60
	4	102	4	0	3.90±0.54
	5	72	4	0	3.86±0.72
I Am Proficient In Applying Clinical Assessment Scales Such As Plaque And Gingival İndices.	3	102	4	1	3.64±0.81
	4	102	4	0	3.98±0.60
	5	72	4	0.25	4.00±0.79
I Can Correctly Classify Advanced Findings Such As Mobility And Furcation Retention.	3	102	4	1	3.58±0.74
	4	102	4	1	3.66±0.72
	5	72	4	1	3.82±0.64
I Am Confident In My Ability To Diagnose Periodontal Diseases.	3	100	4	1	3.46±0.74
	4	102	4	1	3.78±0.56
	5	72	4	0	3.93±0.70
I Am Confident In Treating Periodontal Diseases.	3	100	4	1	3.58±0.65
	4	102	4	1	3.78±0.62
	5	72	4	0	3.97±0.75
I Can Overcome The Challenges I Encounter İn The Diagnosis And Treatment Of Periodontal Diseases	3	100	4	1	3.54±0.69
	4	102	4	1	3.66±0.62
	5	72	4	0	3.83±0.77
I Can Adequately Explain To Patients The Relationship Between Periodontal Disease And Oral Hygiene.	3	100	4	0	4.08±0.63
	4	102	4	0	4.14±0.55
	5	72	4	1	4.21±0.53
During My Periodontology Course, I Received Sufficient Theoretical Training On The Diagnosis Of Periodontal Diseases.	3	100	4	0	3.88±0.64
	4	102	4	0	4.05±0.64
	5	72	4	1	4.04±0.80
I Had Access To Additional Resources (Books, Articles, Online,etc.) Related To The Diagnosis Of Periodontal Diseases.	3	100	4	1	3.50±0.89
	4	102	4	1	3.68±0.80
	5	72	4	0	3.94±0.77

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The Practical Training Opportunities Related To The Diagnosis Of Periodontal Diseases (Laboratory Work, Clinical Applications) Were Sufficient.	3	100	4	1	3.53±0.87
	4	102	4	1	3.74±0.77
	5	72	4	0	3.86±.0.80
I Need More Training And Practice Opportunities İn Diagnosing Periodontal Diseases.	3	102	4	1	3.57±0.88
	4	102	4	1	3.66±0.75
	5	72	4	1	3.44±1.08
I Believe That The New Classification And Current Diagnostic Methods Are Sufficient For The Diagnosis Of Periodontal Diseases.	3	102	4	1	3.59±0.84
	4	102	4	1	3.59±0.75
	5	72	4	1	3.71±0.64
In The Future, I Would Like To Specialize İn The Early Diagnosis Of Periodontal Diseases	3	102	3	1	3.24±1.03
	4	102	4	1	3.67±0.96
	5	72	4	1	3.61±0.93

Table 3. Distribution of responses to questions by class and relationships between them

	3rd Grade Mean#	4th Grade Mean#	5th Grade Mean#	P Value	P_FDR
I Have Sufficient Theoretical Knowledge Regarding The Diagnosis Of Periodontal Diseases.	3.70	3.97	4	0.002	0.01*
I Can Identify The Risk Factors For Periodontal Diseases.	3.98	3.98	4.14	0.21	0.27
I Can Explain The Effect Of Systemic Disease Findings On The Diagnosis Of Periodontal Disease.	3.86	3.79	3.99	0.31	0.35
I am Knowledgeable About The Prevention And Treatment Of Periodontal Diseases.	3.85	3.94	4.08	0.07	0.11
I Can Explain The Risk Of Smoking İn Relation To Periodontal Disease.	4.06	4.13	4.25	0.21	0.27
I Can Establish A Relationship Between Periodontal And Systemic Diseases.	3.84	3.95	4.06	0.07	0.11
I Can Correctly Classify Periodontal Diseases	3.59	3.89	3.84	0.02	0.04*
I Am Competent In Assessing The Severity Of Periodontal Diseases.	3.57	3.79	3.84	0.02	0.04*
I Can Accurately Determine Attachment Loss İn Periodontal Diseases.	3.75	3.65	3.82	0.75	0.78
I Can Accurately Determine Radiographic Bone Loss İn Periodontal Diseases.	3.77	3.75	3.95	0.26	0.33
I Can Use The İnstruments Required For Diagnosing Periodontal Disease Correctly And Effectively.	3.77	3.97	3.97	0.09	0.13
I Can Follow A Systematic Approach When Evaluating Periodontal Diseases.	3.58	3.90	3.86	0.001	0.01*
I Am Proficient In Applying Clinical Assessment Scales Such As Plaque And Gingival Indices..	3.64	3.98	4	0.003	0.01*
I Can Correctly Classify Advanced Findings Such As Mobility And Furcation Retention.	3.58	3.67	3.82	0.06	0.11
I Am Confident In My Ability To Diagnose Periodontal Diseases.	3.46	3.78	3.93	6.15	0.001*
I Am Confident In Treating Periodontal Diseases.	3.58	3.78	3.97	0.001	0.004*
I Can Overcome The Challenges I Encounter In The Diagnosis And Treatment Of Periodontal Diseases	3.54	3.67	3.83	0.01	0.03*
I Can Adequately Explain To Patients The Relationship Between Periodontal Disease And Oral Hygiene.	4.08	4.14	4.21	0.29	0.35
During My Periodontology Course, I Received Sufficient Theoretical Training On The Diagnosis Of Periodontal Diseases.	3.88	4.05	4.04	0.08	0.12
I Had Access To Additional Resources (Books, Articles, Online,etc.) Related To The Diagnosis Of Periodontal Diseases.	3.67	3.67	3.94	0.002	0.01*
The Practical Training Opportunities Related To The Diagnosis Of Periodontal Diseases (Laboratory Work, Clinical Applications) Were Sufficient.	3.53	3.74	3.86	0.002	0.04*
I Need More Training And Practice Opportunities In Diagnosing Periodontal Diseases.	3.57	3.66	3.45	0.98	0.98
I Believe That The New Classification And Current Diagnostic Methods Are Sufficient For The Diagnosis Of Periodontal Diseases.	3.59	3.66	3.45	0.45	0.50
In The Future, I Would Like To Specialize İn The Early Diagnosis Of Periodontal Diseases.	3.24	3.67	3.61	0.01*	0.04*

Since all median values for the questions were 4, only the more meaningful mean values (Mean_Y3, Mean_Y4, Mean_Y5) are presented In the table. The ordinal trend was evaluated using the Jonckheere-Terpstra test, and statistical significance was accepted at $p < 0.05$* after FDR correction.

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Table 4. Distribution of responses to questions by class and relationships between them

		3rd Grade Mean			4th Grade			5th Grade				
		n	%	%S.	n	%	%S.	n	%	%S.	Test statistic	P Value
The Biggest Challenges I Face in Diagnosing Periodontal DIsease Are As Follows.	Lack of theoretical knowledge	51a	48.1	52.0	24b	22.6	23.5	31a	29.2	44.3	50.6**	<0.001*
	Difficulty in measuring the depth of the pocket	15a	37.5	15.3	10a	25.0	9.8	15a	37.5	21.4		
	Inability to distinguish between a fake pocket and a real pocket	46a	35.1	46.9	58a	44.3	56.9	27a	20.6	38.6		
	Inability to establish a connection with systemic diseases	21a	38.9	21.4	17a	31.5	16.7	16a	29.6	22.9		
	Concern about misdiagnosis	72a	43.1	73.5	62a	37.1	60.8	33b	19.8	47.1		
	Fear of not being able to treat after diagnosis	30a	39.5	30.6	26a	34.2	25.5	20a	26.3	28.6		
	Difficulty In diagnosing the radiographic image of periodontal loss	24a	38.7	24.5	25a	40.3	24.5	13a	21.0	18.6		
	Patient-related cooperation deficit	41a	29.9	41.8	54a	39.4	52.9	42a	30.7	60.0		
	Shortage/Insufficiency of materials and supplies	21a	30.9	21.4	30a	44.1	29.4	17a	25.0	24.3		

*p<0.05, **Multiple Chi-squared test., p: Fisher–Freeman–Halton exact test. %S indicates the percentage of students. Different superscript letters (a, b) indicate statistically significant differences.

Theoretical knowledge: Students reported increasing confidence in their theoretical understanding of periodontal disease diagnosis (3.70 → 3.97 → 4.00, P_FDR = 0.01).

Clinical knowledge level: Ability to correctly classify periodontal diseases (3.59 → 3.89 → 3.84, P_FDR = 0.04) and knowledge level in assessing disease severity (3.57 → 3.79 → 3.84, P_FDR = 0.04) improved across academic years.

Systematic evaluation and clinical skills: Students' ability to follow a systematic approach in evaluating periodontal diseases (3.58 → 3.90 → 3.86, P_FDR = 0.01) and proficiency in applying clinical assessment scales such as plaque and gingival indices (3.64 → 3.98 → 4.00, P_FDR = 0.01) also increased significantly.

Confidence in practice: Self-reported confidence in diagnosing (3.46 → 3.78 → 3.93, P_FDR = 0.001) and treating periodontal diseases (3.58 → 3.78 → 3.97, P_FDR = 0.004), as well as the ability to overcome challenges encountered in diagnosis and treatment (3.54 → 3.67 → 3.83, P_FDR = 0.03), showed significant upward trends.

Educational resources and training: Access to additional resources such as books, articles, and online materials increased (3.67 → 3.67 → 3.94, P_FDR = 0.01), and students rated practical training opportunities in laboratory and clinical settings as more sufficient in later years (3.53 → 3.74 → 3.86, P_FDR = 0.04).

Future specialization: Interest in specializing in early diagnosis of periodontal diseases also increased across years (3.24 → 3.67 → 3.61, P_FDR = 0.04).

Items that did not yield statistically significant (P_FDR > 0.05) trends included identification of risk factors, explaining systemic disease effects, accurately determining attachment or radiographic bone loss, understanding smoking-related risk, and perception of the sufficiency of theoretical training, indicating these areas were relatively stable across academic years.

These findings suggest that senior students exhibit a progressively higher level of confidence and knowledge level in both theoretical knowledge and clinical skills related to periodontal diagnosis, although some areas -such as the perceived need for addi-

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tional training- remain relatively consistent across academic years.

Regarding the item “The biggest challenges I face in diagnosing periodontal disease are,” 52% of third-year students, 23.5% of fourth-year students, and 44.3% of fifth-year students reported “lack of theoretical knowledge” as a primary challenge. This indicates a markedly higher rate of confidence in knowledge in the fourth year compared with the third and fifth years. Conversely, concern about misdiagnosis was reported by 73.5% of third-year students, 60.8% of fourth-year students, and 47.1% of fifth-year students, demonstrating a clear decline in this concern among students in the year (Table 4).

DISCUSSION

Periodontal diseases are still the second most common cause of tooth loss. For the proper treatment of individuals with periodontal diseases, accurate diagnosis of the disease is essential. The knowledge and skills of dentists and dental students in this area are of great importance. Despite various studies measuring diagnosis and awareness of periodontal diseases, uncertainties regarding the subject still exist.

Since our periodontology theory courses begin in the third year, our study included third-, fourth-, and fifth-year students. Similar to our study, a study conducted on dental students at the University of Canada included third- and fourth-year students taking periodontology courses.[10]

In the general and theoretical knowledge section of our study, students’ perception of theoretical knowledge on the definition of periodontal diseases increased significantly as they progressed through years. In another study evaluating periodontal disease diagnoses by faculty members, assistant physicians, and students in different classes, it was also observed that students made more accurate diagnoses as their training level increased.[9] In another study, health sciences students’ knowledge of periodontal health was found to be at a “moderate to high” level, but deficiencies were highlighted, particularly in key clinical knowledge areas.[14] This also suggests that as the training level increases, students’ course load, exposure to practice, and consequently the frequency of encountering theoretical content also increases. However, this result may also stem from students’ perception of their scientific self-confidence. In a survey conducted among third- and fourth-year dental students, although their knowledge level was assessed as adequate, they still reported uncertainty regarding diagnosis and treatment planning.[10] Therefore, it should not be forgotten that increased perception may not necessarily mean increased actual knowledge level. No significant difference was observed in the responses between grades for other general information and theoretical questions.

The significant improvements observed in students’ ability to correctly classify periodontal diseases and accurately assess disease severity across academic years align with existing evidence indicating that knowledge level in periodontology develops progressively with increased clinical exposure. Previous studies have shown that the integration of theoretical knowledge with hands-on clinical experience enhances students’ ability to distinguish between periodontal health, gingivitis, and various stages of periodontitis.[15] Accurate classification requires the interpretation of multiple clinical parameters-probing depths, attachment loss, radiographic bone levels, and risk factors- skills that typically strengthen through repeated supervised practice. Similarly, competence in evaluating disease severity has been reported to improve as students advance in their training, as senior students demonstrate greater familiarity with diagnostic indices and more confidence in interpreting complex clinical findings.[16] Thus, the significant upward trend identified in our study suggests that the curriculum effectively supports the acquisition of advanced diagnostic skills, particularly in later years when students have increased opportunities to apply theoretical concepts in real clinical scenarios. A study published in 2025 found that dental students were more proficient in the classification of periodontal diseases than postgraduate dental students who were not periodontists. It was concluded that this difference may be due to postgraduate students having completed their undergraduate education before the 2017 classification came into effect.[18] In another survey study evaluating the periodontal disease classification skills of students from different dental schools, no significant difference was observed between universities.[16]

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In this study, both the ability to follow a systematic approach in periodontal evaluation and the competency in applying clinical assessment scales such as plaque and gingival indices showed statistically significant improvement across academic years. This upward trend likely reflects the progressive development of diagnostic reasoning that accompanies increased clinical exposure during dental training. Previous research has emphasized that structured clinical education plays a critical role in shaping students' diagnostic frameworks; for instance, the 2017 periodontal classification system proposed by Panos N. Papapanou highlights the importance of adopting a stepwise and systematic diagnostic approach, which has been shown to enhance students' ability to organize and interpret periodontal findings.[18] Furthermore, studies assessing periodontal diagnostic skills indicate that hands-on, structured clinical training enhances students' proficiency in using standardized assessment tools. Kayaalti-Yuksek *et al*.[19] demonstrated that preclinical hands-on periodontal instrumentation training significantly improved students' clinical performance compared with theoretical instruction alone, underscoring the value of practical exposure in skill acquisition. Similarly, Pasupuleti *et al*.[20] reported that dental students' competency in periodontal examination, including plaque and gingival assessment, improved over time with increased clinical experience and supervised practice. Together, these findings support the present study's observation that diagnostic proficiency strengthens as students engage more deeply in patient-based learning.

No significant differences were observed between class years in other clinical applications or skill-based questions, indicating that certain competencies progress similarly across the curriculum. Evidence from the literature supports this interpretation. A study evaluating periodontal probing skills among preclinical students showed that hands-on practical training is substantially more effective than traditional theoretical instruction in improving probing accuracy and overall learning.[1] Likewise, a survey assessing peri-implantitis diagnosis and treatment protocols found that final-year dental students possessed a moderate level of knowledge and clinical ability in these areas, demonstrating foundational understanding, even if full proficiency had not yet been achieved.[23] When considered alongside the present findings, these studies suggest that while students consistently develop basic periodontal skills, achieving higher-level konowledge level requires continued structured clinical exposure and reinforcement throughout their training.

Students' self-assessment responses indicated that confidence in diagnosing periodontal diseases, performing periodontal treatment, and overcoming challenges encountered during diagnosis and therapy significantly increased with advancing academic year. Similar findings have been reported in the literature; for instance, Lane *et al*.[23] found that dental students' confidence in performing periodontal assessments and treatments improved steadily as they progressed through the curriculum, highlighting the positive impact of structured clinical experience and guided practice on students' self-efficacy. Similarly, Wong KL *et al*. [16] found that both undergraduate and postgraduate dental students exhibited higher levels of knowledge and agreement on periodontal diagnoses as their training advanced.

In addition, students' confidence in treating periodontal diseases was notably higher among final-year students. In a study by Rigo L. *et al*.[24], students were found to be insufficiently competent in the diagnosis and treatment of dental fluorosis. Similarly, a survey conducted among Saudi Arabian dental students indicated that while students were relatively proficient in diagnosing peri-implantitis, there were notable differences in treatment competencies across individuals.[23]

Our study further demonstrated that as students progressed to higher academic levels, they were more effective in overcoming difficulties encountered during the diagnosis and treatment process, with this relationship being statistically significant. In contrast, Özden *et al*. [25] evaluated the confidence levels of undergraduate dental students at different stages of root canal treatment and reported that fourth-year students exhibited higher confidence than fifth-year students, possibly due to the greater number of procedures performed by fourth-year students compared to their fifth-year counterparts. Moreover, a case-based study involving dental students, orthodontists, and periodontists revealed that although students possessed foundational knowledge in di-

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agnosis and treatment, they still exhibited gaps and misconceptions in clinical decision-making.[26]

In the present study, significant differences were observed across academic years in students' perceptions of educational resources and training opportunities. Specifically, upper-year students reported greater access to supplementary periodontal learning materials and considered the availability of hands-on training opportunities for periodontal diagnosis during clinical sessions to be more adequate compared with lower-year. We believe that increased access may positively influence their perceptions of diagnosis and treatment planning. Another study supporting our findings reported that more education and courses provide positive contributions to physicians in disease diagnosis and treatment.[27]

In the present study, thirdyear students reported a significantly lower interest in specializing in the early diagnosis and management of periodontal diseases compared with fourth and fifthyear students. This differential interest likely reflects the evolving clinical exposure and professional identity development that occurs throughout dental training. Previous research has identified that increased exposure to clinical periodontal procedures, elective courses, and specialty rotations is associated with greater student interest in pursuing advanced periodontal education. For example, a survey of periodontics department chairs in U.S. dental schools indicated that predoctoral clinical rotations, elective periodontal courses, and externship opportunities were key factors influencing whether students applied to periodontal residency programs, suggesting that structured clinical experiences during undergraduate training may enhance students' inclination toward specialization.[28] In contrast to the findings of our study, a survey-based study conducted among dental students reported that third-year students indicated the greatest perceived future need for specialization in the periodontal field, whereas fourth-year students reported the least need.[29] This discrepancy may reflect differences in curriculum structure, clinical exposure, or institutional emphasis on periodontal education across programs.

Based on the responses to the final multiple-choice question, when evaluating the difficulties encountered in diagnosing periodontal diseases, it was observed that the rate of theoretical knowledge deficiency was significantly higher among third- and fifth-year students. This finding suggests that the development and retention of theoretical knowledge may not always follow a strictly linear pattern across academic years. One possible explanation is that, as students progress to higher grades, educational activities become increasingly focused on clinical practice and patient management, potentially reducing opportunities for the reinforcement of previously acquired theoretical knowledge. In addition, knowledge that is not regularly reviewed or applied may gradually decline over time. A similar observation has been reported in the literature. In a 2025 survey evaluating dental students' knowledge and awareness of oral cancer, fifth-year students were significantly less likely than third- and fourth-year students to identify obesity as a risk factor for cancer.[30] This finding indicates that knowledge gaps may persist in specific areas despite increasing academic seniority and clinical experience. Therefore, advancement in educational level does not necessarily guarantee a proportional increase in all domains of theoretical knowledge.This finding suggests that gaps in foundational knowledge may persist at specific stages of dental education, highlighting the need for targeted reinforcement of theoretical concepts alongside clinical training. Our findings suggest that diagnostic accuracy improves with increasing clinical experience, supporting the importance of practical and case-based education. However, the persistence of certain theoretical knowledge gaps among senior students highlights the need for continuous reinforcement of theoretical concepts throughout dental training.

In the multiple-choice questions related to misdiagnosis, fifth-year students reported significantly greater confidence in their ability to establish a correct diagnosis compared with third- and fourth-year students. This finding may be attributed to increased clinical exposure and hands-on experience acquired during the later stages of dental education. Similarly, a previous questionnaire-based study reported that students felt more competent in performing root planing procedures after completing their clinical training.[31] A study demonstrating that students show lower confidence in complex clinical restorative procedures highlights the impact of

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clinical experience on knowledge level.[32] These findings suggest that increasing clinical experience may enhance students' perceived knowledge level and confidence in both diagnostic decision-making and clinical procedures.

This study has some methodological limitations. First, since the data were collected through self-reporting, they may not fully reflect the students' actual clinical knowledge level and diagnostic skills. The fact that the study was conducted at a single center limits the representativeness of the sample and reduces the generalizability of the results to different educational programs. Furthermore, curriculum differences between grade levels may have created a potential impact on the findings by leading to non-homogeneous theoretical and clinical experiences among students. Additionally, participants were recruited through a voluntary, non-random convenience sampling approach. Therefore, selection bias cannot be entirely ruled out, and the findings should be interpreted with caution when extrapolating the results to broader populations of dental students.

CONCLUSION

This study demonstrates that dental students' confidence and knowledge level in diagnosing and managing periodontal diseases generally increase with academic progression. Upper-year students benefited from greater access to educational resources and hands-on clinical training, resulting in higher self-efficacy. Nonetheless, gaps in theoretical knowledge and practical skills persisted at certain stages, highlighting the need for targeted reinforcement. These findings emphasize the value of structured, case-based, and supervised clinical training in developing both competency and confidence, preparing students for independent periodontal diagnosis and treatment.

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CONFLICTS OF INTEREST STATEMENT

The authors declare no conflicts of interest.

REFERENCES

1. Abbas F, Van der Velden U, Hart AA, Moorer WR, Vroom TM, Scholte G. Bleeding/plaque ratio and the development of gingival inflammation J Clin Periodontol 1986;13:774-82.

2. Al-Hussaini R, Al-Kandari M, Hamadi T, Al-Mutawa A, Honkala S, Memon A. Dental health knowledge, attitudes and behaviour among students at the Kuwait University Health Sciences Centre Med Princ Pract 2003;12:260-5.

3. Abraham SN, Malaviya R. Mast cells in infection and immunity. Infect Dis Immun 1997;65:3501-8.

4.Ertümer E.,Karacaoğlu F.,Akkaya M. Ankara Üniversitesi Diş Hekimliği Fakültesine Başvuran Hastaların Periodontal Hastalık Öz Bildirim Geçerliliğinin Değerlendirilmesi. Selçuk Dent J 2018;5:39-49.

5. McGuire MK, Scheyer ET. A Referral-based periodontal practice-Yesterday, today, and tomorrow J Periodontol 2003;74:1542-4.

6. Lee JH, Bennett DE, Richards PS, Inglehart MR. Periodontal referral patterns of general dentists: lessons for dental education. J Dent Educ 2009;73:199-210.

7. Dockter KM, Williams KB, Bray KS, Cobb CM. Relationship between prereferral periodontal care and periodontal status at time of referral. J Periodontol 2006;77:1708-16.

8. Williams KB, Burgardt GJ, Rapley JW, Bray KK, Cobb CM. Referring periodontal patients: clinical decision making by dental and dental hygiene students. J Dent Educ 2014;78:445-53.

9. John V, Lee SJ, Prakasam S, Eckert GJ, Maupome G. Consensus training: an effective tool to minimize variations in periodontal diagnosis and treatment planning among dental faculty and students.J Dent Educ 2013;77:1022-32.

10. Mofidi A, Perez A, Kornerup I, Levin L, Ortiz S, Lai H, *et al*. Dental Students' Knowledge, Confidence, Ability, and Self-Reported Difficulties in Periodontal Education: A Mixed Method Pilot Study. Dent J (Basel) 2022;10;63

11. Friesen LR, Walker MP, Kisling RE, Liu Y, Williams KB. Knowledge of risk factors and the periodontal disease-systemic link in dental students' clinical decisions. J Dent Educ 2014;78:1244-51.

12. Faul F, Erdfelder E, Buchner A, Lang AG. Statistical power analyses using G*Power 3.1: tests for correlation and regression analyses. Behav Res Methods 2009;41:1149-60.

13. Cohen J. Statistical power analysis for the behavioral sciences: routledge; 2013.

14. Aranda Rischmoller J, Acosta Vargas SF, Alegre Rubina YN, Casas Apayco LC. [Knowledge level of periodontal health in students of health sciences. a cross-sectional study. Rev Cient Odontol (Lima) 2024;12:e186.

15. Bamashmous S, Farahat A, Alharbi W, Banjar A, Jamjoom A, Badahdah A. Impact of knowledge of the 2017 classification for periodontal and peri-implant diseases on diagnostic accuracy among dental students. Front Dent Med 2025;6:1558380.

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16. Gandhi KK, Katwal D, Chang J, Blanchard S, Shin D, Maupome G, *et al.* Diagnosis and treatment planning using the 2017 classification of periodontal diseases among three dental schools. J Dent Educ 2022;86:1521-8.

17. Wong KL, Lee YC, Lew PH. The New Periodontal Disease Classification: Level of Knowledge and Agreement on Periodontal Diagnoses Among Dental Undergraduates and Postgraduates in a Private Dental School in Kuala Lumpur—A Cross-sectional Pilot Study. J Appl Oral Sci 2025;11:9-15.

18. Papapanou PN, Sanz M, Buduneli N, Dietrich T, Feres M, Fine DH, *et al.* Periodontitis: Consensus report of workgroup 2 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions J Clin Periodontol 2018;45:162-70

19. Besiroğlu-Turgut E, Agirman M, Keles GC. Effect of preclinical training in periodontal instrumentation on undergraduate students' anxiety, clinical performance, satisfaction. BMC Oral Health 2025;25:1167.

20. Pasupuleti MK, Ramesh K, Vivek B, Vinnakota K. Competency-Based Assessment of Periodontal Examination Skills of Dental Students in Comprehensive Clinics-an Observational Study. Cumhuriyet Dent J 2025;28:1-8.

21. Feng XH, Zhang YL, Liu KN, Zhao YB, Hu WJ. [Exploration of training pattern on periodontal probing during pre-clinical periodontal practice of undergraduate students]. Zhonghua Kou Qiang Yi Xue Za Zhi 2017;52:641-4.

22. Madi M, Tabassum A, Attia D, Al Muhaish L, Al Mutiri H, Alshehri T. *et al*. Knowledge and attitude of dental students regarding etiology, diagnosis, and treatment of peri-implantitis. J Dent Educ 2024;88:100-8.

23. Lane BA, Luepke P, Chaves E, Maupome G, Eckert GJ, Blanchard S, *et al*. Assessment of the calibration of periodontal diagnosis and treatment planning among dental students at three dental schools. J Dent Educ 2015;79:16-24.

24. Rigo L, Lodi L, Garbin RR. Differential diagnosis of dental fluorosis made by undergraduate dental students. Einstein (Sao Paulo) 2015;13:547-54.

25. Ozden I, Gokyar M, Ozden ME, Ovecoglu HS. Evaluation of confidence levels of undergraduate dental students in various stages of root canal treatment BMC Med Educ 2025;25:567.

26. Abou-Arraj RV, Kaur M, Alkhoury S, Swain TA, Geurs NC, Souccar NM. The new periodontal disease classification: Level of agreement on diagnoses and treatment planning at various dental education levels. J Dent Educ 2021;85:1627-39.

27. Darby IB, Angkasa F, Duong C, Ho D, Legudi S, Pham K, *et al*. Factors influencing the diagnosis and treatment of periodontal disease by dental practitioners in Victoria Aust Dent 2005;50:37-41.

28. Satheesh KM, Brockmann LB, Liu Y, Gadbury-Amyot CC. Use of an Analytical Grading Rubric for Self-Assessment: A Pilot Study for a Periodontal Oral Competency Examination in Predoctoral Dental Education. J Dent Educ 2015;79:1429-36.

29. Eskin E. Diş Hekimliği Fakültesi Öğrencilerinin Periodontoloji Uzmanlığına Bakış Açılarının Değerlendirilmesi Anketi. Aydin Dent J 2025;11:127-37

30. Yüksel İ B, Bahrilli S, Altındağ A. Turkish dental students' knowledge, attitudes, and awareness of oral cancer. BMC Cancer 2025;25:568.

31. Brundin M, Sjöström M. Student confidence in clinical competence during dental education. BDJ Open 2024;10:92.

32. Hattar S, AlHadidi A, Altarawneh S, Hamdan AAS, Shaini FJ, Wahab FK. Dental students' experience and perceived confidence level in different restorative procedures Eur J Dent Educ 2021;25:207-14.

Diş Hekimliği Öğrencilerinin Periodontal Hastalık Tanısı Bilgi Düzeylerinin Değerlendirilmesi: Kesitsel Bir Anket Çalışması

ÖZET

Amaç: Bu çalışmada 3., 4. ve 5. sınıf öğrencilerinin periodontal teşhis bilgi düzeylerini değerlendirmek amaçlanmıştır.

Gereç ve Yöntemler: Bu kesitsel anket çalışmasında, periodontal hastalıkların tanımlanması ve sınıflandırılması, klinik değerlendirme, tanı–tedavi sürecine ilişkin güven, klinik ölçeklerin uygulanması, kaynaklara erişim ve uzmanlaşma isteğini kapsayan 25 maddelik bir anket uygulanmıştır. Veriler tanımlayıcı istatistikler (frekans ve yüzde) ile özetlenmiştir. Tüm istatistiksel analizler R yazılımı (sürüm 4.5.1) kullanılarak gerçekleştirilmiştir. Akademik yıllar (3., 4. ve 5. sınıf) arasında ordinal eğilimler Jonckheere-Terpstra testi ile değerlendirilmiş, etki büyüklüğü olarak Kendall's tau kullanılmıştır. Çoklu karşılaştırmalar için Benjamini–Hochberg yanlış keşif oranı (FDR) düzeltmesi uygulanmıştır. Çoktan seçmeli maddeler multiple Chi-squared testi ile analiz edilmiştir. İstatistiksel anlamlılık için $p < 0.05$ kabul edilmiştir.

Bulgular: Ordinal eğilim analizi (Jonckheere-Terpstra), FDR düzeltmesi sonrası 24 maddenin 13'ünde akademik yıllara göre Likert puanlarında anlamlı artış gösterdi ($P < 0.05$). Etki büyüklükleri küçük olmakla birlikte (Kendall's $\tau = 0.13$ to 0.25), tutarlı bir yükseliş gözlendi ve üst sınıflarda daha yüksek katılım düzeyine işaret etti. Tanısal zorluklara ilişkin geribildirimler sınıflara göre farklılık göstermiş; teorik bilgi eksikliği 3. sınıfta %48.1 iken 4. sınıfta %22'ye düşmüş, yanlış tanı koyma kaygısı ise 5. sınıf öğrencilerinde en düşük düzeyde (%19.8) saptanmıştır. Bu bulgular, eğitim ilerledikçe tanısal yeterliliğin arttığını düşündürmektedir.

Sonuç: Akademik yıllar boyunca gözlenen yukarı yönlü eğilim, konuya ilişkin artan aşinalık ve üst sınıf öğrencilerinin daha fazla klinik deneyime sahip olmasını yansıtmaktadır. Bulgular, anketle değerlendirilen algıların müfredatın ileri yıllarında kademeli olarak

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güçlendiğini ve periodontal değerlendirmeye yönelik yetkinlik ve özgüvenin aşamalı biçimde geliştiğini göstermektedir.

Anahtar Kelimeler: Diş Hekimliği Öğrencileri; Kesitsel Çalışmalar; Parametrik Olmayan İstatistikler; Periodontal Hastalıklar; Periodontal Tanı

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Original Research Article

Effect of Low-Concentration Chlorhexidine Mouthrinses on the Microleakage of Class V Resin Composite Restorations: An *In Vitro* Study

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ABSTRACT

Aim: This *in vitro* study investigated the effect of two daily-use mouthrinses containing 0.05% chlorhexidine (CHX), with or without cetylpyridinium chloride (CPC), on the microleakage of standardized Class V resin composite restorations.

Materials and Methods: Forty-five sound human premolars were included. Standardized non-beveled Class V cavities were prepared on the buccal surfaces and restored using a universal adhesive system and resin composite. After finishing, polishing, and thermocycling (1000 cycles, 5–55 °C), specimens were randomly assigned to three groups (n = 15): artificial saliva (control), CHX-only mouthrinse, and CHX + CPC mouthrinse. To simulate cumulative exposure equivalent to one year of daily use, each specimen was immersed in the assigned solution for 12 h. After methylene blue dye immersion and buccolingual sectioning, microleakage was assessed by stereomicroscopic examination at 40× magnification using an ordinal scoring system. The data were analyzed using the Kruskal-Wallis test, followed by Mann-Whitney U tests for pairwise comparisons when appropriate. Statistical significance was set at $p < 0.05$.

Results: Mean microleakage scores were 1.80 ± 0.46 in the control group, 2.80 ± 0.65 in the CHX group, and 2.77 ± 0.62 in the CHX + CPC group. A statistically significant difference was observed among the groups ($p < 0.001$). Both CHX-containing mouthrinse groups showed significantly higher microleakage than the control group ($p < 0.001$), whereas no significant difference was found between the CHX and CHX + CPC groups ($p = 0.87$).

Conclusion: Within the limitations of this study, prolonged exposure to low-concentration CHX-containing mouthrinses may compromise the marginal integrity of class V resin composite restorations.

Keywords: Chlorhexidine gluconate; Composite dental resin; Dental leakage; Mouthwashes.

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INTRODUCTION

Resin-based composite restorations represent a fundamental component of contemporary restorative dentistry, owing to their superior esthetic properties, minimally invasive application protocols, and ongoing advancements in material science. Notwithstanding these advantages, the long-term clinical performance of composite restorations remains critically influenced by marginal integrity, with microleakage constituting one of the principal factors compromising restoration longevity.[1] Microleakage, defined as the clinically imperceptible diffusion of oral fluids, ions, and microorganisms across the tooth-restoration interface, is implicated in the pathogenesis of secondary caries, postoperative hypersensitivity, and premature restorative failure.[2,3] Accordingly, the identification and characterization of biological and chemical determinants influencing microleakage are of considerable clinical and scientific importance.

In periodontal practice, chemical plaque control is routinely advocated as an adjunct to mechanical debridement, particularly in clinical scenarios characterized by impaired plaque removal, such as post-periodontal therapy, acute gingival inflam-

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mation, or diminished patient compliance with oral hygiene measures.[4] In such contexts, antiseptic mouthrinses are frequently prescribed for adjunctive short-term use, whereas low-concentration chlorhexidine (CHX) formulations may be recommended for sustained daily application in selected cases.[5] Among available antiseptic agents, CHX is widely regarded as the gold standard, supported by substantial evidence demonstrating its efficacy in plaque inhibition and gingivitis control. Comparative evaluations have further indicated that CHX exhibits superior antiplaque performance relative to essential-oil-based mouthrinses[6] and a modest advantage over cetylpyridinium chloride (CPC), particularly under conditions where mechanical plaque control is absent.[7] Moreover, combination formulations incorporating low concentrations of CHX and CPC have been shown to achieve plaque-regrowth inhibition comparable to higher-concentration CHX regimens, while exhibiting a more favorable tolerability profile.[8]

In routine clinical settings, the repeated or prolonged use of CHX-containing mouthrinses inevitably results in continuous exposure of existing restorative materials to both the active agent and auxiliary formulation components.[4] From a periodontal perspective, the morphology and adaptation of restorative margins -particularly within the cervical region- exert a decisive influence on local biofilm dynamics and gingival inflammatory status by modulating plaque retention and surface cleanability.[9] Longitudinal clinical observations further suggest that restored tooth surfaces may be associated with comparatively less favorable periodontal outcomes, thereby underscoring the critical importance of achieving optimal marginal adaptation in plaque-sensitive regions.[10]

This consideration is particularly pertinent in class V restorations, wherein cervical lesions frequently extend toward or beyond the cementoenamel junction (CEJ), resulting in margin placement on dentin or cementum within a biologically vulnerable, plaque-prone environment.[11,12] It is well established that margins located on dentin and cementum demonstrate inferior sealing ability and increased susceptibility to microleakage when compared to enamel margins.[11] Consequently, the preservation of cervical marginal integrity in Class V restorations represents a persistent and clinically significant challenge. Furthermore, marginal discrepancies -such as subgingival margin placement, overcontoured restorations, or subtle interfacial defects- may exacerbate plaque accumulation and contribute to adverse periodontal sequelae.[9,13]

Although CHX is extensively prescribed for its antiplaque and antigingivitis properties, *in vitro* evidence suggests that exposure to CHX-containing mouthrinses may influence the physicochemical properties of resin-based materials, including surface roughness, microhardness, and color stability, with potential implications for both biofilm accumulation and esthetic performance.[14] Moreover, certain investigations have indicated that CHX-containing mouthrinses may adversely affect marginal adaptation or increase microleakage, with these effects appearing to be dependent on concentration, application protocol, and the specific adhesive system employed.[15] Conversely, other studies have reported that low-concentration CHX formulations used in routine daily mouthrinses exert negligible effects on restorative performance.[16]

Despite these findings, the available evidence remains heterogeneous with respect to CHX concentration, exposure protocols, restorative materials, and methodological approaches, thereby limiting the generalizability of the findings to routine clinical practice.[5,17,18] Previous studies have primarily focused on changes in the surface properties of restorative materials,[14,15] the effects of antimicrobial pretreatments,[19,20] or microleakage under specific experimental conditions such as bleaching protocols,[18] rather than evaluating the influence of commercially available low-concentration CHX mouthrinses intended for prolonged daily use on marginal integrity.

In particular, commercially available 0.05% CHX mouthrinses formulated for long-term daily use have received limited attention, despite being routinely recommended to selected periodontal patients.[5] Furthermore, it remains uncertain whether the incorporation of CPC into these formulations influences the marginal integrity of existing composite restorations during prolonged exposure. Addressing this question is clinically relevant because CHX/CPC formulations are increasingly prescribed as daily-use antiseptic mouthrinses to improve tolerability while maintaining antimicrobial efficacy.

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Therefore, the present *in vitro* study aimed to evaluate the effect of two commercially available daily-use mouthrinses containing 0.05% CHX, one containing CHX alone and the other combining CHX with CPC, on the microleakage of standardized class V composite restorations with cervical margins located approximately 1 mm above the CEJ. By evaluating commercially available 0.05% daily-use CHX mouthrinses with and without CPC, this study may contribute to a better understanding of their potential effects on the marginal integrity of composite restorations following prolonged exposure to products intended for daily use.

The null hypothesis was that microleakage would not differ significantly among the groups exposed to the CHX-containing mouthrinses and the artificial-saliva control.

MATERIALS AND METHODS

Tooth selection and sample size determination

A total of 45 intact human premolars extracted for orthodontic or periodontal reasons were obtained for this *in vitro* study. Ethical approval was granted by the Trakya University Non-Interventional Scientific Research Ethics Committee (Approval No: TUTF-GOBAEK 2025/539), and all procedures followed the Declaration of Helsinki. Prior to extraction, patients provided written consent allowing the use of their discarded teeth for research.

Teeth with caries, restorations, previous endodontic treatment, visible structural defects such as cracks or fractures, or developmental anomalies were not included. After extraction, residual soft tissues were removed, and the specimens were cleaned and disinfected in chloramine solution. The teeth were then maintained in distilled water at 37 °C until testing, for a standardized storage period of 7 to 10 days.

Sample size determination was performed using G*Power software (Heinrich Heine University, Düsseldorf, Germany), based on an effect size derived from a previous study.[19] Using an estimated effect size of f = 0.5, a two-sided α level of 0.05, and a statistical power of 80% (1−β = 0.80), the minimum required sample size was calculated as 45 specimens. Accordingly, 15 teeth were allocated to each group to ensure adequate statistical power to detect anticipated intergroup differences.

Tooth preparation

Non-beveled class V cavities were prepared on the buccal surfaces of all premolar specimens using a high-speed handpiece under continuous water cooling. Cavities were prepared to standardized dimensions of 3 mm mesiodistal width, 2 mm occlusogingival height, and 2 mm axial depth, based on a previously described design.[20] Dimensions were confirmed using a color-marked periodontal probe (Michigan Williams type; Hu-Friedy, Chicago, IL, USA) (Figure 1). The occlusal margin was placed in enamel, and the cervical margin was positioned approximately 1 mm coronal to the CEJ.

All restorative procedures were performed by a single calibrated operator following the manufacturers' instructions. A universal adhesive system (Bond

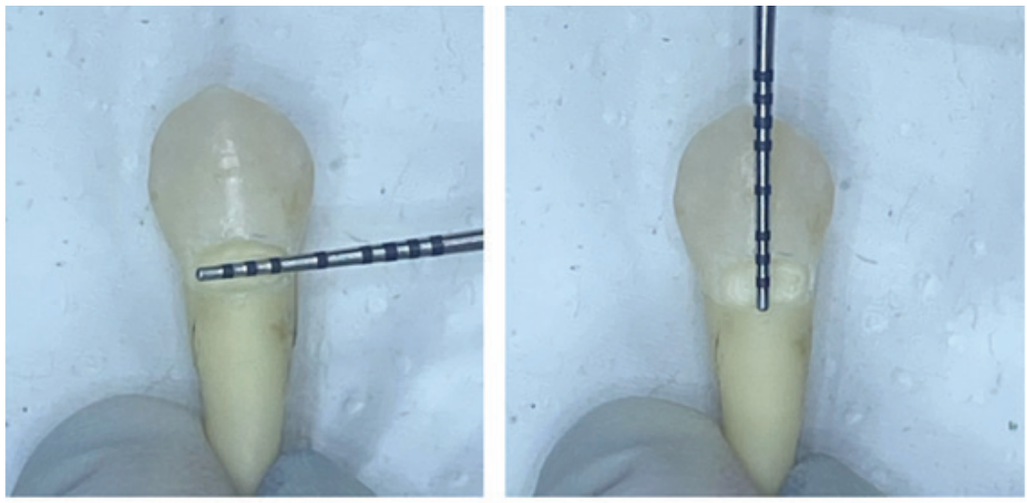


Figure 1. Measurement of standardized class V cavity dimensions using a color-coded periodontal probe.

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Force II, Tokuyama Dental Corp., Tokyo, Japan) was applied, gently air-thinned, and light-cured using a LED curing unit (Elipar DeepCure-S, 3M ESPE, St. Paul, MN, USA). The cavities were restored with a universal resin composite (Estelite Sigma Quick, shade A2; Tokuyama, Japan) placed in a single increment because the cavity depth did not exceed 2 mm, and polymerization was completed using the same LED curing unit. Light output was checked after each use with a calibrated radiometer (SDI Radiometer, SDI, Germany).

Following restoration, specimens were stored in distilled water at 37 °C for 24 h. Finishing was performed with a 12-fluted carbide bur (SS White Burs Inc., Lakewood, NJ, USA), and polishing was completed using a multi-step composite polishing system (Diatech Plus, Coltene, Switzerland) according to the manufacturer's recommendations. Artificial aging was then carried out by thermocycling for 1000 cycles between 5 °C and 55 °C (Thermocycler THE 1100, SD Mechatronik, Feldkirchen-Westerham, Germany), with a dwell time of 30 s and a transfer time of 10 s.

Experimental groups

The specimens were randomly assigned to three experimental groups (n = 15 per group) according to the immersion medium:

Group 1 (Control): Artificial saliva prepared in accordance with ASTM E2720 and ISO 10271 standards (Testonic Laboratories, Colin Kimya San. Tic. A.Ş., Istanbul, Turkey).

Group 2 (CHX): DentaSave Klorhex mouthrinse (DentaSave®; Drogsan, Ankara, Turkey), an alcohol-free mouthrinse containing 0.05% chlorhexidine digluconate.

Group 3 (CHX + CPC): Perio-Aid Active Control mouthrinse (Perio-Aid®; Dentaid, Spain), an alcohol-free mouthrinse containing 0.05% chlorhexidine digluconate and 0.05% cetylpyridinium chloride.

To simulate cumulative exposure corresponding to approximately one year of daily clinical use, each specimen was immersed once in the assigned solution for a total duration of 12 h under standardized laboratory conditions.

Preparation for microleakage assessment

Dye penetration was restricted to the tooth–restoration interface by sealing the apical openings when applicable and applying two layers of surface varnish, leaving an uncoated band of approximately 1 mm around the restoration margins. Specimens were subsequently immersed in 2% methylene blue solution for 24 h at room temperature.[19,21] After dye immersion, the specimens were rinsed thoroughly with running water, lightly air-dried, and embedded in acrylic resin to allow standardized sectioning. Buccolingual sections were obtained under continuous water cooling using a precision cutting device (Isomet 2000, Buehler, USA). Three longitudinal sections-one central and two peripherals-were obtained from each specimen.

Microleakage scoring

Dye penetration at both occlusal and cervical margins was assessed using a digital stereomicroscope (SZ61, Olympus Corp., Japan) at 40× magnification by a blinded and calibrated examiner. For each specimen, the maximum dye penetration noted across the three sections was used for analysis.

Microleakage was graded using an ordinal scoring system as follows:[19]

0 = No dye penetration observed
1 = Dye penetration limited to less than half of the cavity wall depth
2 = Dye penetration reaching approximately half of the cavity wall depth
3 = Dye penetration extending beyond half of the cavity wall depth without involving the pulpal floor
4 = Dye penetration reaching the pulpal floor.

Statistical analysis

Microleakage data were processed in SPSS Statistics (version 31; IBM Corp., Armonk, NY, USA). Intra-observer agreement was assessed using the Kappa statistic. Microleakage scores were treated as ordinal data and summarized as median and range values. Accordingly, differences among groups were evaluated using the Kruskal-Wallis test, with Mann-Whitney U tests applied for post hoc pairwise comparisons when indicated. Statistical significance was set at $p<0.05$.

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RESULTS

The Kappa coefficient was determined to be 0.913, indicating an excellent level of intra-observer reliability. Descriptive statistics for microleakage scores across the experimental groups are summarized in Table 1.

Among the experimental groups, the CHX-only mouthrinse group exhibited the highest median microleakage score (median = 2.50; range, 1.50–4.00), followed by the CHX + CPC mouthrinse group (median = 2.50; range, 1.50 to 3.50). In contrast, the artificial saliva (control) group demonstrated the lowest median microleakage score (median = 1.50; range, 1.00 to 2.50) (Figures 2-4).

The Kruskal–Wallis test revealed a statistically significant difference among the three groups ($H = 18.4$, $df = 2$, $p < 0.001$), indicating that the storage solution had a significant influence on marginal microleakage. Microleakage scores in the CHX-only group were significantly higher than those in the artificial saliva (control) group ($U = 25.0$, $Z = -3.71$, $p < 0.001$), (Figure 4). Similarly, the CHX + CPC group exhibited significantly greater microleakage compared with the artificial saliva (control) group ($U = 26.0$, $Z = -3.71$, $p < 0.001$). However, no statistically significant difference was observed between the two chlorhexidine-containing mouthrinse groups (Denta Save Klorhex vs. Perio-Aid Active Control), ($U = 108.0$, $Z = -0.19$, $p = 0.87$).

Table 1. Descriptive statistics of microleakage scores by experimental groups

Group	n	Mean ± SD	Median	Min–Max	p
Control	15	1.80 ± 0.46^{A}	1.50	1.00–2.50	$<0.001^{*}$
CHX-only	15	2.80 ± 0.65^{B}	2.50	1.50–4.00	
CHX + CPC	15	2.77 ± 0.62^{B}	2.50	1.50–3.50	

Kruskal-Wallis test: $H = 18.4$, $^{*}p < 0.05$. Different uppercase letters indicate significant differences between groups. CHX, chlorhexidine; CPC, cetylpyridinium chloride.

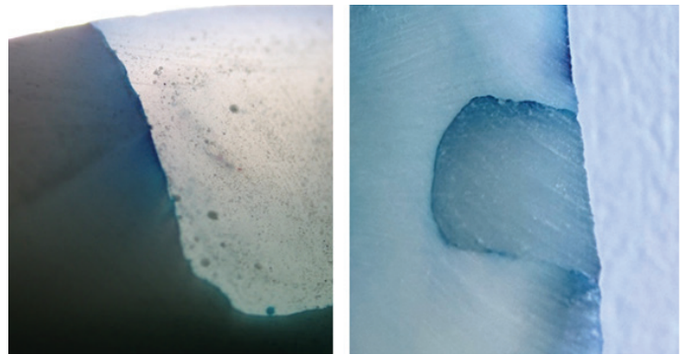


Figure 2. Representative stereomicroscope image and microphotograph from the CHX-only group showing a score of 4, with dye penetration extending beyond half of the cavity wall depth and reaching the pulpal floor.

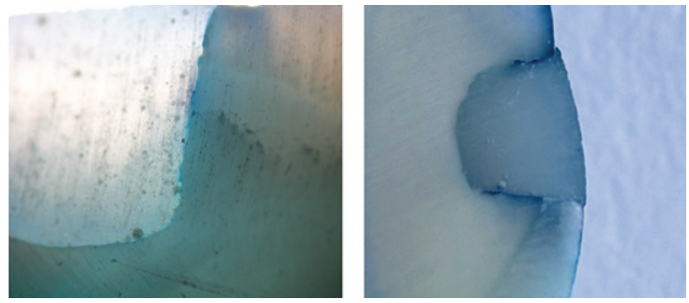


Figure 3. Representative stereomicroscope image and microphotograph of a specimen from the CHX + CPC group showing a score of 3, characterized by dye penetration extending more than half of the cavity wall depth but not reaching the pulpal floor.

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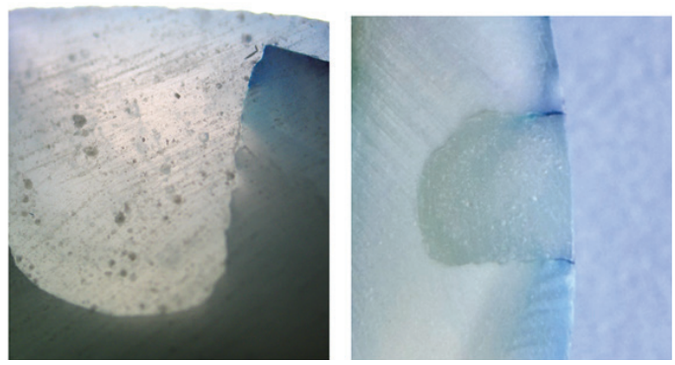


Figure 4. Representative stereomicroscope image and microphotograph of a specimen from the artificial saliva (control) group showing a score of 1, characterized by dye penetration extending less than half of the cavity wall depth.

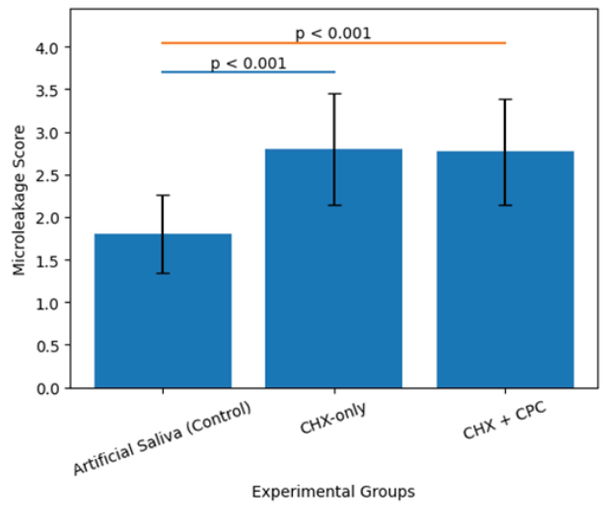


Figure 5. Microleakage scores of composite restorations after exposure to different storage solutions. Bars represent the mean microleakage scores, and error bars indicate standard deviations.

DISCUSSION

The present *in vitro* study evaluated the effect of commercially available, daily-use, low-concentration (0.05%) CHX mouthrinses, with or without CPC, on microleakage of standardized class V composite restorations. The results demonstrated that both CHX-containing mouthrinses significantly increased marginal microleakage compared with the control group immersed in artificial saliva, whereas no significant difference was observed between the CHX-only and CHX + CPC groups. These findings suggest that prolonged exposure to low-concentration CHX formulations, regardless of CPC content, may compromise the marginal integrity of class V composite restorations.

Resin-based composites are widely preferred in the restoration of cervical lesions due to their favorable esthetic properties and minimally invasive application protocols. However, their long-term clinical success remains closely linked to the stability of the adhesive interface. Interfacial degradation may arise from a combination of polymerization shrinkage stress, thermal fluctuations, mechanical loading, and material-specific physicochemical characteristics.[11] These processes can compromise marginal adaptation over time, thereby contributing to clinically relevant complications such as marginal discoloration, postoperative sensitivity, and an increased risk of secondary caries.[22]

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The increased microleakage observed in the CHX-exposed groups suggests that prolonged exposure to CHX-containing mouthrinses can affect the stability of the tooth-restoration interface. One possible explanation is that repeated exposure to aqueous mouthrinse solutions can facilitate processes associated with hydrolytic aging of the adhesive interface. Previous studies have shown that hydrolytic aging of the hybrid layer is characterized by gradual resin degradation and collagen breakdown, which may ultimately compromise the long-term durability of adhesive restorations.[23,24] Although CHX has been widely recognized for its sustained antimicrobial effect and potential to inhibit matrix metalloproteinases,[25] its long-term interaction with polymeric restorative interfaces remains complex and may vary depending on the concentration, mode of application, adhesive strategy, and duration of exposure. However, the mechanisms underlying the present findings remain speculative and warrant further investigation.

Microleakage in composite restorations is inherently multifactorial. Factors such as cavity configuration (C-factor), orientation and density of dentinal tubules, intrinsic moisture of dentin, and the chemical composition of adhesive systems all influence the quality of hybrid layer formation and subsequent marginal sealing.[11] In particular, self-etch adhesive systems can exhibit limitations related to incomplete smear layer modification, suboptimal demineralization, and insufficient resin infiltration into the collagen matrix. These characteristics have been associated with reduced long-term bond durability and may render the bonded interface more susceptible to degradation during aging processes.[23,24] Because a mild self-etch adhesive system was used, prolonged mouthrinse exposure may have further challenged this interface. However, this interpretation remains hypothetical, as bond strength and ultrastructural changes were not evaluated.

In the present study, microleakage assessment was based on the maximum dye penetration observed, irrespective of margin location. Although cavity preparations were standardized with cervical margins positioned approximately 1 mm coronal to the CEJ, thereby remaining within enamel, evidence of microleakage was also observed at the cervical margin. This finding can be related to the reduced thickness and structural characteristics of cervical enamel, which may compromise the quality and durability of the adhesive interface compared with thicker enamel regions. This observation is consistent with the broader understanding that cervical areas represent a structurally and functionally more vulnerable zone for marginal sealing.[22] Even when margins are confined to enamel, the transitional nature of the cervical region, combined with its proximity to dentin and cementum, can adversely affect bonding performance.[26] Consequently, the cervical margin can still be considered a relative “weak point” in terms of marginal integrity, playing a critical role in the periodontal-restorative interface.[11,12] Furthermore, under clinical conditions, this region is particularly susceptible to contamination from gingival crevicular fluid, which may interfere with adhesive procedures and compromise bonding effectiveness.[27] Although these clinical conditions were not reproduced in the present *in vitro* model, they can further contribute to marginal deterioration and affect the long-term performance of cervical restorations, particularly in plaque-retentive environments.

It is important to emphasize that no currently available restorative material or adhesive strategy is capable of completely eliminating microleakage, particularly at dentin margins. Consistent with previous investigations, marginal leakage has been reported to persist regardless of the restorative material, placement technique, or adhesive approach employed. This underscores the inherently multifactorial nature of interfacial degradation and the challenges associated with achieving a durable seal at the tooth-restoration interface.[11,28]

Various strategies have been proposed to improve marginal adaptation and reduce polymerization shrinkage stress, including incremental placement techniques, flowable composite liners, reinforcing fibers, and different adhesive strategies.[29–31] Although these approaches may improve marginal sealing under certain conditions, their effectiveness depends on several factors, including the restorative material, adhesive strategy, cavity configuration, and operator technique. In particular, the beneficial effect of reinforcing fibers appears to be limited when self-etch adhesive systems are used.[31] Moreover, total-etch adhesive strategies, particularly when combined with incremental composite placement, have gener-

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ally been associated with lower microleakage than self-etch approaches in class V composite restorations.[32] Therefore, the use of a mild self-etch adhesive system without selective enamel etching or beveling may have contributed to the baseline level of microleakage observed in the present study. However, because the same restorative protocol was applied to all specimens, this factor is unlikely to explain the differences observed among the experimental groups.

The increased microleakage observed following exposure to CHX-containing mouthrinses is generally consistent with previous *in vitro* studies suggesting that mouthrinse solutions may influence the behavior of restorative materials. Ajami *et al*.[18] likewise reported increased microleakage following exposure to CHX-containing mouthrinses. Although both studies demonstrated a detrimental effect on marginal sealing, direct comparison should be made cautiously because their study was performed after bleaching treatment and employed different adhesive systems and experimental conditions. In contrast, the present study specifically evaluated prolonged exposure to commercially available 0.05% CHX mouthrinses intended for daily use, representing a different experimental scenario. In addition, mouthrinse solutions have been shown to alter the surface properties of resin-based composites, including surface roughness, microhardness, and color stability,[14,15] changes that may indirectly influence biofilm accumulation and the local microenvironment surrounding restorations. Similarly, previous studies have shown that the effects of antibacterial agents on marginal integrity vary according to the adhesive strategy, restorative material, and experimental protocol employed,[19] which may partly explain the heterogeneous findings reported across studies.

No statistically significant difference was detected between the CHX-only and CHX + CPC groups, suggesting that the observed increase in microleakage was primarily associated with CHX exposure rather than with the addition of CPC. Nevertheless, the possibility of subtle inter-product differences cannot be entirely excluded because such effects may remain undetected due to the inherent limitations of ordinal dye-penetration scoring systems, which are constrained in terms of sensitivity and discriminatory capacity. Although CPC is frequently incorporated into low-concentration CHX mouthrinses to enhance antiplaque efficacy and improve tolerability,[5,33] evidence regarding its influence on the marginal integrity of resin-based restorations remains limited. Most available studies have focused on the physicochemical properties of restorative materials rather than microleakage,[34] while one previous study evaluating CPC and dye penetration employed substantially different experimental conditions, limiting direct comparison with the present findings.[35] Taken together, these findings suggest that the addition of CPC did not measurably influence microleakage under the experimental conditions evaluated. However, this interpretation should be made cautiously, as different restorative materials, adhesive systems, CPC concentrations, and exposure protocols may influence the observed outcomes.

Importantly, the present findings should be interpreted within the limitations of an *in vitro* study and should not be considered a contraindication to the clinical use of CHX-containing mouthrinses, given their well-established efficacy in plaque control and periodontal therapy. Because this study employed a prolonged immersion protocol, the extent to which the observed increase in microleakage reflects clinical performance remains uncertain. Nevertheless, maintenance of marginal integrity remains particularly important in cervical restorations because these restorations are frequently located in plaque-retentive areas where access for effective mechanical plaque control may be limited. Accordingly, CHX use should continue to be guided by clear clinical indications, with attention to duration of use and routine monitoring of restoration margins during supportive periodontal care.[4,9,36]

Certain methodological aspects of the present study should also be considered. The absence of selective enamel etching, lack of beveling at enamel margins, and the use of a self-etch adhesive system may have influenced the bonding effectiveness and contributed to the observed microleakage patterns. These factors should be taken into account when interpreting the results and comparing them with studies employing different adhesive strategies.

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Several limitations should also be acknowledged. As an *in vitro* investigation, the study does not fully replicate the complex biological and mechanical conditions of the oral environment, including salivary dynamics, biofilm interactions, and functional loading. Additionally, microleakage was assessed using an ordinal dye-penetration method, which, although widely accepted, has intrinsic limitations in sensitivity and reproducibility. The findings are inherently limited to the specific materials and experimental protocols employed; accordingly, generalization to alternative restorative systems or clinical scenarios should be approached with caution. Finally, microleakage represents an indirect indicator of marginal integrity and does not necessarily correlate directly with clinical performance or periodontal outcomes.

CONCLUSION

Within the inherent limitations of this *in vitro* investigation, prolonged exposure to low-concentration CHX-containing mouthrinses was found to be associated with increased microleakage in cervical class V composite restorations, irrespective of the presence of CPC. These findings suggest a potential adverse effect of sustained antiseptic exposure on the integrity of the resin–dentin interface. However, given the controlled experimental conditions and the surrogate nature of microleakage assessment, caution is warranted in extrapolating these results directly to clinical practice. Further well-designed *in vivo* studies are required to clarify the clinical significance of these observations and to elucidate the long-term interactions between antiseptic mouthrinses and restorative interfaces under dynamic oral conditions.

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ChatGPT 5.6 (OpenAI) was used solely for language editing and improving the clarity of the manuscript. All AI-assisted edits were carefully reviewed by the authors, who take full responsibility for the final content.

COMPETING INTERESTS

The authors declare that they have no competing interests.

REFERENCES

1. Zotti F, Falavigna E, Capocasale G, De Santis D, Albanese M. Microleakage of direct restorations: comparison between bulk-fill and traditional composite resins: systematic review and meta-analysis. Eur J Dent 2021;15:755–67.

2. Gupta N, Singh N. Restorations of Class II cavities evaluated for marginal leakage when restored with composites or a giomer using different bonding agents. Int J Periodontics Restorative Dent 2023;43:129–45.

3. Muliyar S, Shameem KA, Thankachan RP, Francis PG, Jayapalan CS, Hafiz KAA. Microleakage in endodontics. J Int Oral Health 2014;6:99–104.

4. James P, Worthington HV, Parnell C, Harding M, Lamont T, Cheung A, *et al*. Chlorhexidine mouthrinse as an adjunctive treatment for gingival health. Cochrane Database Syst Rev 2017;3:CD008676.

5. Escribano M, Herrera D, Morante S, Teughels W, Quirynen M, Sanz M. Efficacy of a low-concentration chlorhexidine mouth rinse in non-compliant periodontitis patients attending a supportive periodontal care programme: a randomized clinical trial. J Clin Periodontol 2010;37:266–75.

6. Van Leeuwen MPC, Slot DE, Van der Weijden GA. Essential oils compared to chlorhexidine with respect to plaque and parameters of gingival inflammation: a systematic review. J Periodontol 2011;82:174–94.

7. Windhorst ER, Joosstens M, Van der Sluijs E, Slot DE. The effect of cetylpyridinium chloride compared to chlorhexidine mouthwash on scores of plaque and gingivitis: a systematic review and meta-analyses. Int J Dent Hyg 2025;23:665–81.

8. Mor-Reinoso C, Pascual A, Nart J, Quirynen M. Inhibition of de novo plaque growth by a new 0.03% chlorhexidine mouth rinse formulation applying a non-brushing model: a randomized, double blind clinical trial. Clin Oral Investig 2016;20:1459–67.

9. Nugala B, Kumar BS, Sahitya S, Krishna PM. Biologic width and its importance in periodontal and restorative dentistry. J Conserv Dent 2012;15:12–7.

10. Nafz P, Kocher T, Pink C, Baumeister S, Reckelkamm S, Samietz S, *et al*. Associations between restoration margins and adjacent periodontal status—longitudinal results from SHIP-TREND. J Clin Periodontol 2026;53:520-28.

11. Sooraparaju SG, Kanumuru PK, Nujella SK, Konda KR, Reddy KBK, Penigalapati S. A comparative evaluation of microleakage in Class V composite restorations. Int J Dent 2014;2014:685643.

12. Luong E, Shayegan A. Assessment of microleakage of Class V restored by resin composite and resin-modified glass ionomer and pit and fissure resin-based sealants following Er:YAG laser conditioning and acid etching: *in vitro* study. Clin Cosmet Investig Dent 2018;10:83–92.

13. Hausdörfer T, Lechte C, Kanzow P, Rödig T, Wiegand A. Periodontal health in teeth treated with deep-margin-elevation and

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CAD/CAM partial lithium disilicate restorations—a prospective controlled trial. Clin Oral Investig 2024;28:670.

14. Festuccia MSCC, Garcia LFR, Cruvinel DR, Pires-de-Souza FCP. Color stability, surface roughness and microhardness of composites submitted to mouthrinsing action. J Appl Oral Sci 2012;20:200–05.

15. Çelik A, Çoban E, Ülker H. Effects of mouthwashes on color stability and surface roughness of three different resin-based composites. Niger J Clin Pract 2021;24:555–60.

16. Poppolo Deus F, Ouanounou A. Chlorhexidine in dentistry: pharmacology, uses, and adverse effects. Int Dent J 2022;72:269–77.

17. Brookes ZLS, Bescos R, Belfield LA, Ali K, Roberts A. Current uses of chlorhexidine for management of oral disease: a narrative review. J Dent 2020;103:103497.

18. Ajami AA, Bahari M, Oskoee SS, Kimyai S, Kahnamoui MA, Rikhtegaran S, *et al*. Effect of three different mouthrinses on microleakage of composite resin restorations with two adhesive systems after bleaching with 10% carbamide peroxide. J Contemp Dent Pract 2012;13:16–22.

19. Bin-Shuwaish M, AlHussaini A, AlHudaithy L, AlDukhiel S, AlJamhan A, Alrahlah A. Effects of different antibacterial disinfectants on microleakage of bulk-fill composite bonded to different tooth structures. BMC Oral Health 2021;21:348.

20. Hameed H, Babu BP, Sagir VMM, Chiriyath KJ, Mathias J, Shaji AP. Microleakage in resin composite restoration following antimicrobial pre-treatments with 2% chlorhexidine and Clearfil Protect Bond. J Int Oral Health 2015;7:71–6.

21. Wyatt T, Roberts H. Simulated hydrostatic pulpal pressure effect on microleakage—an initial study. Oper Dent 2024;49:290–99.

22. Poggio C, Chiesa M, Scribante A, Mekler J, Colombo M. Microleakage in Class II composite restorations with margins below the CEJ: *in vitro* evaluation of different restorative techniques. Med Oral Patol Oral Cir Bucal 2013;18:793–98.

23. Betancourt DE, Baldion PA, Castellanos JE. Resin-dentin bonding interface: Mechanisms of degradation and strategies for stabilization of the hybrid layer. Int J Biomater. 2019;2019:5268342.

24. Breschi L, Maravic T, Cunha SR, *et al*. Dentin bonding systems: From dentin collagen structure to bond preservation and clinical applications. Dent Mater. 2018;34(1):78-96.

25. Barbosa B, Castro F, Pereira J, Catarino M, Guimarães J, Fernandes GVO. Sensitivity of collagenolytic periopathogenic microorganisms to chlorhexidine solution: a comprehensive review of *in vitro* studies. Microbiol Res 2024;15:2435–54.

26. Silveira de Araújo C, Incerti da Silva T, Ogliari FA, Meireles SS, Piva E, Demarco FF. Microleakage of seven adhesive systems in enamel and dentin. J Contemp Dent Pract 2006;7:26–33.

27. Veneziani M. Adhesive restorations in the posterior area with subgingival cervical margins: new classification and differentiated treatment approach. Eur J Esthet Dent 2010;5:50–76.

28. Jacker-Guhr S, Ibarra G, Oppermann LS, Lührs AK, Rahman A, Geurtsen W. Evaluation of microleakage in Class V composite restorations using dye penetration and micro-CT. Clin Oral Investig 2016;20:1709–18.

29. Alonso RCB, Sinhoreti MAC, Correr Sobrinho L, Consani S, Goes MFD. Effect of resin liners on the microleakage of Class V dental composite restorations. J Appl Oral Sci 2004;12:56–61.

30. Moezyzadeh M, Kazemipoor M. Effect of different placement techniques on microleakage of Class V composite restorations. Front Dent 1;6:121-29.

31. Ahmed W, El-Badrawy W, Kulkarni G, Prakki A, El-Mowafy O. Gingival microleakage of Class V composite restorations with fiber inserts. J Contemp Dent Pract 2013;14:622–28.

32. Owens BM, Johnson WW. Effect of insertion technique and adhesive system on microleakage of Class V resin composite restorations. J Adhes Dent 2005;7:303–08.

33. Quirynen M, Soers C, Desnyder M, Dekeyser C, Pauwels M, Van Steenberghe D. A 0.05% cetylpyridinium chloride/0.05% chlorhexidine mouth rinse during maintenance phase after initial periodontal therapy. J Clin Periodontol 2005;32:390–400.

34. Bernaldo-Faustino JL, Dulanto-Vargas JA, Carranza-Samanez KM. *In vitro* effect of mouthrinses on the microhardness of three different nanohybrid composite resins. Int J Dent 2023;2023:9161639.

35. Ziskind D, Gleitman J, Rotstein I, Friedman M. Evaluation of cetylpyridinium chloride for infection control in storage solution. J Oral Rehabil 2003;30:477–81.

36. Schätzle M, Lang NP, Ånerud Å, Boysen H, Bürgin W, Löe H. The influence of margins of restorations on the periodontal tissues over 26 years. J Clin Periodontol 2001;28:57–64.

Düşük Konsantrasyonlu Klorheksidin İçeren Ağız Gargaralarının Sınıf V Rezin Kompozit Restorasyonlarda Mikrosızıntı Üzerine Etkisi: *In Vitro* Bir Çalışma

ÖZET

Amaç: Bu *in vitro* araştırmada, %0,05 klorheksidin (CHX) içeren ve setilpiridinyum klorür (CPC) içeriğine göre farklılık gösteren iki günlük kullanım ağız gargarasının, standardize edilmiş Sınıf V rezin kompozit restorasyonlarda mikrosızıntı üzerindeki etkisi incelenmiştir.

Gereç ve Yöntemler: Çalışmada 45 sağlıklı insan premoları kullanıldı. Bukkal yüzeylere standart, bevelsiz Sınıf V kaviteler hazırlanarak üniversal adeziv sistem ve rezin kompozit ile restore edildi. Bitim ve polisajın ardından örnekler termal siklusa (1000

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siklus, 5–55 °C) tabi tutuldu ve yapay tükürük (kontrol), yalnızca CHX içeren gargara ve CHX + CPC içeren gargara olmak üzere rastgele üç gruba ayrıldı (n = 15). Bir yıllık günlük kullanım eşdeğerini simüle etmek amacıyla her örnek ilgili solüsyonda 12 saat tutuldu. Metilen mavisi ile boyama ve bukkolingual yönde kesit alma işlemlerinin ardından, mikrosızıntı 40× büyütmede stereomikroskobik inceleme ile ordinal bir skor sistemi kullanılarak değerlendirildi. Gruplar arasındaki mikrosızıntı farklılıkları Kruskal-Wallis testi kullanılarak analiz edildi, gerekli durumlarda ikili karşılaştırmalar için Mann-Whitney U testleri uygulandı. İstatistiksel anlamlılık düzeyi $p < 0.05$ olarak kabul edildi.

Bulgular: Ortalama mikrosızıntı skorları kontrol grubunda 1.80 ± 0.46, CHX grubunda 2.80 ± 0.65 ve CHX + CPC grubunda 2.77 ± 0.62 idi. Gruplar arasında istatistiksel olarak anlamlı fark gözlendi ($p < 0.001$). CHX içeren her iki gargara grubu, kontrol grubuna göre anlamlı olarak daha yüksek mikrosızıntı gösterdi ($p < 0.001$); buna karşın CHX ve CHX + CPC grupları arasında anlamlı fark bulunmadı ($p = 0.870$).

Sonuç: Bu çalışmanın sınırlılıkları dahilinde, düşük konsantrasyonlu CHX içeren ağız gargaralarına uzun süreli maruziyet sınıf V rezin kompozit restorasyonların marjinal bütünlüğünü etkileyebilir.

Anahtar Kelimeler: Dental sızıntı; Gargaralar; Klorheksidin glukonat; Kompozit dental rezin.

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Case Report

Peripheral Giant Cell Granuloma: A Case Report and Review of Pediatric Reactive Mucosal Lesions with Clinicopathological Correlations

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ABSTRACT

Introduction: Peripheral giant cell granuloma (PGCG) is an uncommon reactive lesion in children that may demonstrate aggressive behavior and recurrence. This study presents a pediatric case and provides a narrative review of reactive oral mucosal lesions in the pediatric population.

Case Report: A 9-year-old boy presented with gingival enlargement in anterior maxilla. Clinical examination revealed excessive plaque accumulation along with rotational malalignment of the maxillary incisor and increased overjet, potentially contributing to plaque retention and chronic mechanical irritation. The lesion was surgically excised and histopathologically diagnosed as PGCG. Recurrence occurred at 11 weeks, requiring deeper excision. No further recurrence was observed during 18-month follow-up.

Conclusion: The accompanying narrative review highlights differences in prevalence, histopathology, and recurrence tendencies among common pediatric reactive lesions. Compared with other entities, PGCG demonstrates a relatively higher recurrence potential. Early diagnosis, complete excision, elimination of etiological factors, and interdisciplinary follow-up are essential to minimize recurrence risk.

Keywords: Histopathology; Pediatric reactive mucosal lesions; Peripheral giant cell granuloma

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INTRODUCTION

Reactive lesions of the oral cavity are non-neoplastic proliferations that develop as an exaggerated response of the connective tissue to chronic irritation, local trauma, or other persistent stimuli. While they are generally benign, their rapid growth, tendency to recur, and clinical resemblance to more aggressive lesions may pose diagnostic and therapeutic challenges, particularly in the pediatric population.[1,2]

In children, reactive oral mucosal lesions present additional challenges due to ongoing craniofacial growth, mixed dentition, behavioral factors affecting oral hygiene, and psychosocial considerations.[3,4] Common reactive lesions reported in the pediatric population include pyogenic granuloma (PG), irritation fibroma (IF), peripheral ossifying fibroma (POF), and peripheral giant cell granuloma (PGCG), all of which share similar etiological factors but differ in histopathological features and recurrence tendencies.[5, 6]

PGCG is a relatively uncommon reactive lesion that arises exclusively on the gingiva or alveolar mucosa and originates from the periodontal ligament or periosteum.[7] While PGCG is more frequently observed in adults, a smaller proportion of cases occur in children, where the lesion may demonstrate more aggressive behavior, including rapid growth, bone involvement, and a higher risk of recurrence.[8, 9]

The aim of this article is to present a case of recurrent peripheral giant cell granuloma in a 9-year-old child and to discuss reactive oral mucosal lesions

in the pediatric population, emphasizing diagnostic considerations, etiological factors, and management strategies.

CASE REPORT

A 9-year-old male patient was referred to the Periodontology Department of University Hospital with the chief complaint of gingival overgrowth in his upper anterior region, which had appeared approximately one month ago. The patient had no systemic diseases and was not under any medications. According to his parents, he had an active lifestyle with adequate nutrition; however, his oral hygiene habits were irregular.

The patient's extraoral examination was normal, without any facial asymmetry. Intraorally, the most notable clinical finding was a prominent, solitary, pedunculated exophytic gingival enlargement with a reddish surface located in the maxillary anterior gingiva extending from teeth #11 to #21, predominantly surrounding tooth #11. The lesion was soft in consistency, exhibited bleeding on gentle periodontal probing, and showed mild superficial ulceration, most likely secondary to occlusal trauma. The patient reported no pain, and no tooth mobility or displacement was detected. Periapical radiographic examination revealed no evidence of superficial bone resorption, interdental bone involvement, tooth displacement, or any other osseous changes. Consistent with the patient's reported oral hygiene habits, generalized dental plaque accumulation was observed. Although the plaque accumulation was mild overall, it was more pronounced in the maxillary anterior region.

Occlusal assessment demonstrated a significantly increased overjet and overbite, which were associated with a convex facial profile (Figure 1).

Based on the clinical findings, a treatment plan was established. Accordingly, the lesion was planned to be completely excised and submitted for histopathological examination. The preliminary clinical diagnosis was inflammatory gingival enlargement, while pyogenic granuloma was included in the differential diagnosis. In addition, potential etiological factors were addressed as part of the comprehensive management strategy; oral hygiene instructions were provided to control plaque accumulation, and an orthodontic appointment was scheduled to evaluate the current occlusal condition. Prior to the excision of the lesion, written informed consent was obtained from the patient's parents.

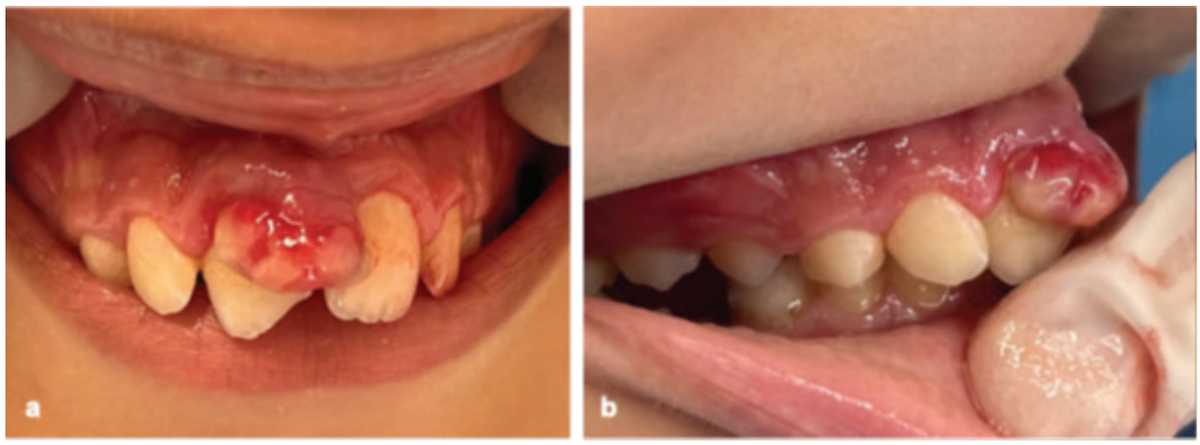


Figure 1. 1a) Baseline front view 1b) Baseline side view

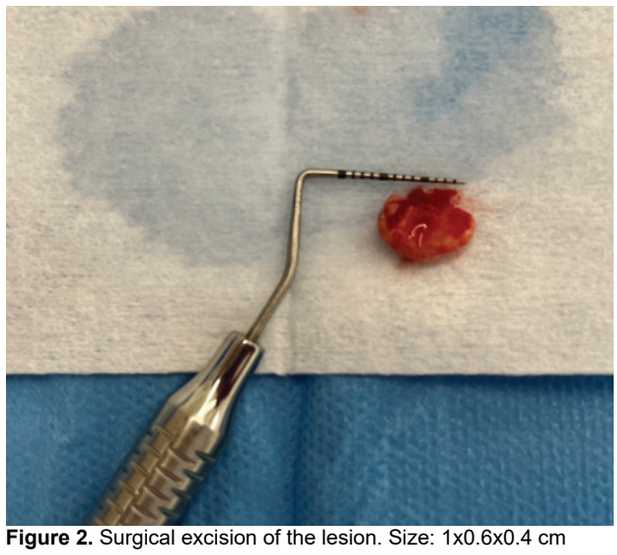


Figure 2. Surgical excision of the lesion. Size: 1x0.6x0.4 cm

Following the complete excision of the lesion to-

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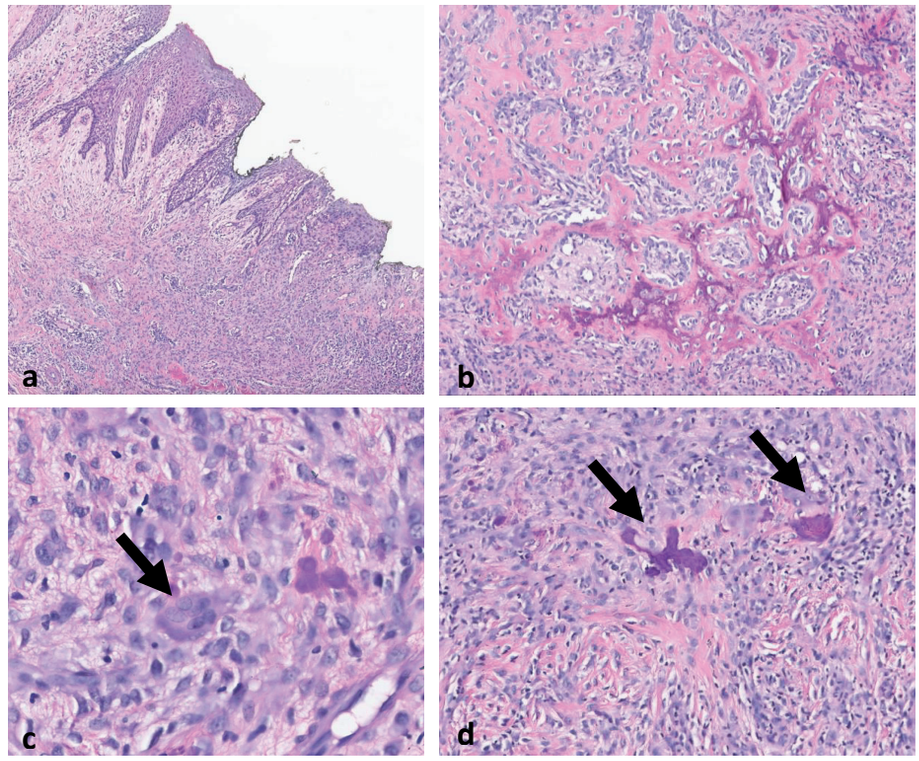


Figure 3. Histopathological evaluation. 3a) Overall architecture of the lesion with overlying squamous epithelium and underlying fibrohistiocytic stroma, H&E. 3b) Woven bone-like calcifications on fibrohistiocytic stroma, H&E. 3c) Multinucleated giant cell (arrow), H&E 3d) Irregular calcifications on fibrohistiocytic stroma, H&E. Images were obtained from digitally scanned slides and enlarged using on-screen magnification; therefore, a standardized magnification factor is not applicable.

gether with its pedunculated stalk using a scalpel with a #15c blade under local anesthesia, the excised specimen measured 1 × 0.6 × 0.4 cm and was submitted for histopathological examination. Histopathological examination confirmed the diagnosis of peripheral giant cell granuloma, which is characterized by the presence of multinucleated giant cells within a vascular and fibroblastic stroma along with woven-bone-like and irregular calcifications (Figures 2 and 3).

Postoperative healing during the 2-week follow-up was uneventful. Furthermore, the patient's oral hygiene was improved with a decreased plaque score. The orthodontic consultation recommended postponing orthodontic intervention until completion of the mixed dentition period and following the patient periodically to perform orthodontic intervention at the appropriate time.

The patient re-presented to the clinic at the 11-week postoperative follow-up with a complaint of lesion recurrence. A deeper surgical excision with a #15c scalpel was subsequently performed under local anesthesia to ensure complete removal of the lesion and its base (Figure 4). The underlying periosteal tissue was curetted to minimize the risk of further recurrence. Considering the previously established histopathological diagnosis of PGCG and the characteristic clinical appearance of the recurrent lesion, the excised recurrent tissue was not submitted for a second histopathological examination.

Healing was uneventful, and no further recurrence of the lesion was observed during the 18-month follow-up. The patient continued to attend regular orthodontic follow-up visits.

DISCUSSION

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Figure 4. 4a) Post-op 11 weeks, recurrence of the lesion 4b) Surgical excision of the recurrent lesion

Reactive oral mucosal lesions in children represent a diagnostically and therapeutically challenging group of conditions due to overlapping clinical features, variable biological behavior, and the influence of growth and development on disease progression. Therefore, a comprehensive understanding of their epidemiology, etiological factors, clinical presentation, histopathological features, and management strategies is essential for accurate diagnosis and optimal treatment planning.

The prevalence of reactive oral mucosal lesions in the pediatric population varies among lesion types (Table 1). PG has been reported in all ages, and when present in the pediatric population, it is most commonly described in children between 7 and 13 years of age.[6,10] Similarly, IF is observed across all age groups, but its prevalence is relatively low and variable in children, depending on age-related and behavioral factors.[5,6] POF, on the other hand, predominantly affects younger individuals and is most frequently encountered during the first and second decades of life, making it a lesion of relevance in the pediatric population.[11] PGCG is most often seen

Table 1. Prevalence and Recurrence Rates of Oral Reactive Mucosal Lesions in the Pediatric Population

Lesion	Pediatric Prevalence	Histopathology	Recurrence Rate	References
Peripheral Giant Cell Granuloma	-34% of cases occur in patients <20 years -9.5% of cases occur in children <10 years -34% reported between 5–15 years	Multinucleated giant cells, vascular stroma, hemosiderin	5–11% Higher recurrence in aggressive/maxillary lesions	Cahuana-Bartra et al., 2023, Volpato et al., 2016, Nekouei et al.,2016, Chandna et al., 2017
Pyogenic Granuloma	Commonly reported in children aged 7–13 years	Capillary proliferation, granulation tissue, inflammatory infiltrate	Not clearly defined in pediatric population	Owczarek-Drabińska et al., 2022, Lomeli Martinez et al., 2023, Chandna et al., 2017
Irritation Fibroma	-Low and variable prevalence in children -Variable frequency in pediatric cohorts	Dense collagen bundles, fibrous connective tissue, hyperkeratotic epithelium	Rare after complete excision	Nair et al., 2020, Owczarek-Drabińska et al., 2022 Nair et al., 2020, Horvat Aleksijević et al., 2022
Peripheral Ossifying Fibroma	Predominantly affects first and second decades	Fibrous stroma, bone/cementum-like calcifications	Higher recurrence when excision is incomplete	Sehgal et al., 2021, Purushothaman et al., 2023, Maymone et al., 2019

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between the third and sixth decades of life and is considered relatively uncommon in children. Approximately one-third of cases occur in patients younger than 20 years of age, with some studies reporting that 34% of these cases occur in individuals between 5 and 15 years old. In children under 10 years, it accounts for only 9.5% of cases.[7,9,12] Thus, our case represents a relatively rare entity in the pediatric population. These epidemiological data underline the importance of evaluating reactive oral lesions in children within a broader clinical and biological context rather than relying solely on age-based prevalence.

In pediatric patients, chronic local irritation and mechanical trauma represent the primary etiological factors underlying lesion development, with common etiological factors including biting habits, fractured or sharp restorations, sharp cuspal tips, ill-fitting orthodontic appliances, food impaction, dental biofilm accumulation, minor trauma related to exfoliation of primary teeth, eruption of permanent teeth, and inadequate oral hygiene practices.[5,6,10,13] These persistent stimuli trigger an exaggerated reparative response within the connective tissue, increasing various reactive lesions whose clinical and histopathological features depend largely on their tissue of origin. IF typically manifests as a fibrotic mass derived from fibrous connective tissue, whereas PG originates from granulation tissue with a prominent vascular component, reflecting its inflammatory nature. POF develops through reactive proliferation within the periodontal ligament, leading to the formation of bone- or cementum-like tissue.[14] Within this shared etiological framework, PGCG represents a hyperplastic reactive lesion arising exclusively on the gingiva or alveolar mucosa and originating from the connective tissue of the periodontal ligament or periosteum, where tissue injury may induce an abnormal proliferative response.[9] In the present case, rotational malalignment of the maxillary incisor in combination with increased overjet may have created a plaque-retentive environment and localized traumatic contacts, contributing to persistent mechanical irritation and subsequent lesion development in the anterior region. In this context, although reactive oral lesions in children share common etiological triggers, differences in tissue origin and biological response account for their distinct histopathological characteristics and clinical behavior.

From a clinical perspective, lesion localization and growth behavior may show overlapping features, while still exhibiting lesion-specific patterns that aid in differential diagnosis. These lesions predominantly involve gingiva or alveolar mucosa, reflecting the role of chronic irritation and trauma in these areas. PGCG typically arises on the gingiva or alveolar mucosa, often anterior to the molar region, and may exhibit relatively rapid and aggressive growth in children, with potential involvement of interdental bone, localized bone resorption, and interference with tooth eruption.[7, 12] PG shares a reactive growth pattern but is distinguished by its highly vascular nature and broader intraoral distribution, as it may also involve the lips, tongue, buccal mucosa, and hard palate in addition to the gingiva.[5,13] In contrast, IF and POF generally demonstrate slower growth and a more localized presentation, most commonly affecting the buccal mucosa along the occlusal plane and the interdental gingiva, respectively, with a predilection for the maxilla in pediatric patients.[5,6,11,14] Variations in growth rate, tissue involvement, and site distribution among reactive oral lesions may complicate clinical differentiation, highlighting the role of histopathological evaluation.

Histopathological evaluation plays a pivotal role in distinguishing reactive oral lesions in children, as shared clinical features may obscure accurate diagnosis. Microscopically, PG is characterized by granulation tissue–like vascular proliferation, with numerous enlarged capillaries and a dense infiltration of chronic inflammatory cells, reflecting its highly vascular and inflammatory nature.[5,10] In contrast, IF exhibits a predominantly fibrotic architecture, marked by dense collagen bundles arranged in radiating or circular patterns with variable fibroblast content; the overlying epithelium may show hyperkeratosis, atrophy, or ulceration depending on the duration and intensity of trauma, and inflammatory infiltrate is usually secondary.[5] POF demonstrates a distinct histopathological profile, consisting of fibrous connective tissue with varying cellularity accompanied by mineralized components, such as bone or cementum-like material, originating from the periodontal ligament.[14,15] Within this spectrum, PGCG shows a unique histomorphology characterized by multinucleated osteoclast-like giant cells dispersed

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within a vascular connective tissue stroma, often accompanied by hemorrhage, hemosiderophages, and inflammatory cells.[16] Accurate histopathological identification of these lesions is critical, as definitive diagnosis directly influences treatment planning and long-term management.

Management of the lesions in pediatric patients is primarily based on complete surgical excision combined with elimination of local etiological factors to reduce the risk of recurrence. For PGCG, early detection and thorough surgical removal, including adequate debridement of the lesion base, are essential to minimize dentoalveolar complications and prevent damage to adjacent teeth and tissues.[7] Similarly, surgical excision remains the treatment of choice for PG and IF, with emphasis on complete removal of the lesion and control of contributing factors such as dental plaque, calculus, and chronic mechanical irritation.[3,5,10] POF likewise requires complete excision, including the lesion base and any involved periodontal ligament or periosteum, as incomplete removal is associated with a higher risk of recurrence.[17] Although treatment modalities, including laser excision, cryosurgery, and corticosteroid injections, have been reported, conventional surgical excision remains the primary and most reliable treatment approach in pediatric patients.[3,5] Across all reactive lesions, early diagnosis, meticulous surgical technique, and elimination of local irritational factors are critical components of successful management in children, helping to prevent recurrence and long-term dentoalveolar complications.[7]

Recurrence is an important clinical consideration in the management of reactive oral lesions in children, and it is closely related to both the adequacy of surgical intervention and the persistence of etiological factors. In the present case, although the lesion was completely excised together with its pedunculated stalk during the initial surgery, curettage of the lesion base and underlying periosteum was not performed, which may have contributed to the observed early recurrence. PGCG is associated with a higher recurrence potential compared with other reactive lesions, with reported recurrence rates generally ranging from 5% to 11%; however, higher rates have been described for aggressive lesions and those located in the maxilla, emphasizing the need for careful long-term follow-up.[7,16] The recurrence risk of PG in children is not clearly defined in the literature, while the recurrence of IF is considered rare, following complete removal and elimination of causative factors.[3] Likewise, POF also demonstrates a tendency for recurrence if excision is incomplete, necessitating complete removal of the lesion, including any involved periosteum or periodontal ligament, and early intervention to prevent dentoalveolar complications such as tooth displacement or bone resorption (Table 1).[7,14,16] Complete surgical excision with adequate removal of the lesion base and curettage, along with elimination of local irritants such as dental plaque, is essential to reduce recurrence risk.[7,14] In addition, reinforcement of oral hygiene and orthodontic evaluation to address the local etiological factors illustrate the importance of an interdisciplinary approach in reducing recurrence risk in pediatric patients.

Rather than merely documenting a rare lesion, this report combines a mini review of pediatric reactive oral mucosal lesions with an illustrative case of peripheral giant cell granuloma, providing clinically relevant insights into their differential diagnosis and management. The presented case highlights the clinical behavior, recurrence potential, and therapeutic challenges of pediatric PGCG, demonstrating how a comprehensive understanding of reactive oral lesions can support accurate diagnosis, appropriate treatment planning, and follow-up. The early postoperative recurrence observed in the present case underscores the importance of complete surgical excision, thorough elimination of local etiological factors, and interdisciplinary management in reducing recurrence risk and preventing dentoalveolar complications. By integrating clinical, histopathological, and therapeutic perspectives, this report offers practical insights that may help clinicians enhance diagnostic accuracy and treatment outcomes for reactive oral lesions in growing patients.

CONCLUSION

Peripheral giant cell granuloma, although relatively rare in children, should be carefully considered in the differential diagnosis of gingival enlargements due to its aggressive clinical behavior and higher recurrence potential compared with other reactive oral lesions. Accurate diagnosis relies on histopathological examination, as clinical features may overlap

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among reactive entities, thus facilitating appropriate treatment planning, preventing dentoalveolar complications, and improving clinical decision-making in children.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

REFERENCES

1. Purushothaman A, Sahana NS, Jayaram C, Shiragur SS, Chavan NV, Kulkarni M. Reactive lesions of oral cavity. J Oral Med Oral Surg Oral Pathol Oral Radiol 2023;9:175-82.

2. Effiom OA, Adeyemo WL, Soyele OO. Focal reactive lesions of the gingiva: an analysis of 314 cases at a tertiary health institution in Nigeria. Niger Med J 2011;52:35-40.

3. Horvat Aleksijević L, Prpić J, Muhvić Urek M, Pezelj-Ribarić S, Ivančić-Jokić N, Peršić Bukmir R, *et al*. Oral mucosal lesions in childhood. Dent J (Basel) 2022;10:42.

4. Vaidya S, Limbu S, Dikshit P, Malla M. Oral pyogenic granuloma in an 11-year-old child: a case report. J South Asian Assoc Pediatr Dent 2023;6:31-4.

5. Nair BM, Basavaraju SM, Pachipulusu B. Reactive hyperplastic lesions of oral cavity: a review of literature. J Health Sci Res 2020;10:42-6.

6. Owczarek-Drabińska JE, Nowak P, Zimoląg-Dydak M, Radwan-Oczko M. The prevalence of oral mucosa lesions in pediatric patients. Int J Environ Res Public Health 2022;19:12156.

7. Nekouei A, Eshghi A, Jafarnejadi P, Enshaei Z. A review and report of peripheral giant cell granuloma in a 4-year-old child. Case Rep Dent 2016;2016:6136421.

8. Flaitz CM. Peripheral giant cell granuloma: a potentially aggressive lesion in children. Pediatr Dent 2000;22:232-3.

9. Cahuana-Bartra P, Brunet-Llobet L, Suñol-Capella M, Miranda-Rius J. Expansive oral giant cell granuloma in a pediatric patient. Int J Clin Pediatr Dent 2023;16:405-8.

10. Gera D, Tanwar A, Nigam AG, Jain S, Sharma V. Pyogenic granuloma in a 6-year-old boy: a rare case report. Int J Contemp Pediatr 2023;10:607-10.

11. Sehgal S, Hassan MJ, Khan S, Ahmad N, Jetley S. An unusual case of peripheral ossifying fibroma of the hard palate. Indian J Pathol Oncol 2021;8:159-61.

12. Patel C, Diwanji A, Mathur J, Purani J. Peripheral giant cell lesion of the oral cavity in a 12-year-old child: a rare case report. J Cancer Res Ther 2024;20:1032-5.

13. Lomeli Martinez SM, Carrillo Contreras NG, Gómez Sandoval JR, Zepeda Nuño JS, Gomez Mireles JC, Varela Hernández JJ, *et al*. Oral pyogenic granuloma: a narrative review. Int J Mol Sci 2023;24:12903.

14. Grand E, Burgener E, Samson J, Lombardi T. Post-traumatic development of a peripheral giant cell granuloma in a child. Dent Traumatol 2008;24:124-6.

15. Volpato LER, Leite CA, Anhesini BH, Aguilera JMGDS, Borges ÁH. Peripheral giant cell granuloma in a child associated with ectopic eruption and traumatic habit with control of four years. Case Rep Dent 2016;2016:4583947.

16. Maymone MBC, Greer RO, Burdine LK, Dao-Cheng A, Venkatesh S, Sahitya PC, *et al*. Benign oral mucosal lesions: clinical and pathological findings. J Am Acad Dermatol 2019;81:43-56.

17. Chandna P, Srivastava N, Bansal V, Wadhwan V, Dubey P. Peripheral and central giant cell lesions in children: institutional experience at Subharti Dental College and Hospital. Indian J Med Paediatr Oncol 2017;38:440-6.

Periferik Dev Hücreli Granülom: Çocuklarda Görülen Reaktif Oral Mukozal Lezyonların Klinikopatolojik Perspektiften Değerlendirilmesi ve Bir Olgu Sunumu

Giriş: Periferik dev hücreli granülom (PDHG), çocuklarda nadir görülen ancak agresif klinik seyir ve rekürrens gösterebilen reaktif bir lezyondur. Bu çalışma pediatrik bir olguyu sunmakta ve reaktif oral mukozal lezyonlara ilişkin bir derleme içermektedir.

Vaka raporu: Dokuz yaşındaki erkek hasta üst anterior bölgede gingival büyüme şikâyetiyle başvurdu. Klinik muayenede yoğun plak birikimi ile birlikte maksiller kesicide rotasyon ve artmış overjet saptandı; bu durumun plak retansiyonu ve kronik mekanik irritasyona katkıda bulunabileceği değerlendirildi. Lezyon cerrahi olarak eksize edildi ve histopatolojik olarak PDHG tanısı doğrulandı. 11. haftada rekürrens izlenmesi üzerine daha derin eksizyon uygulandı. 18 aylık takipte yeniden rekürrens gözlenmedi.

Sonuç: Pediatrik reaktif oral lezyonlar benzer etiyolojik faktörlere sahip olmakla birlikte biyolojik davranış ve rekürrens eğilimleri açısından farklılık gösterir. PDHG'nin görece yüksek rekürrens potansiyeli nedeniyle erken tanı, tam eksizyon ve multidisipliner takip önemlidir.

Anahtar Kelimeler: Histopatoloji; Pediyatrik reaktif mukozal lezyonlar; Periferik dev hücreli granülom

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