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Dear Colleagues,

It is with great pleasure that I welcome you to the first issue of the new year. In this issue, reviews of new developments in the field of dentistry and original researchs are included. One of our most important goals is to mediate appropriately the sharing of knowledge and experience among dental professionals, researchers and academicians. In this issue, we share with you six articles covering various topics in dentistry.

The first article of our journal, ''A bibliometric analysis of the literature on the use of artificial intelligence in pediatric dentistry" is an original article and the authors aimed to conduct a bibliometric analysis of the scientific literature on the use of artificial intelligence (AI) in pediatric dentistry to evaluate publication trends, citation impact, key contributors, and research themes. The second article "Endodontic treatment procedures applied by endodontists and general dentists in Turkiye: a survey study"is an original article. The authors aimed to determine the use of rubber dams, magnification techniques, working length measurement methods, and preferences for multiple sessions among endodontists and general dental practitioners performing root canal treatment in Turkiye, as well as to evaluate disinfection and obturation protocols.

Artificial intelligence (AI) refers to the creation of computer systems capable of performing tasks that typically necessitate human intelligence. Several dental specializations, such as pediatric dentistry, increasingly utilize artificial intelligence and its components, including machine learning and deep learning. The thirth article, "Utilization of artificial intelligence in pediatric dentistry: a comprehensive literature review" is a review. This article provides an overview of the various applications of AI that are advantageous to pediatric dentistry. The fourth article '' Management of surgical treatment with autogenous graft for papilla reconstruction in cases of peri-implant papilla loss: 3-month follow-up'' is a case report. This article describes the use of an autogenous de-epithelialized soft tissue graft (SDG) for papilla reconstruction in a patient who was aesthetically dissatisfied due to papilla loss, along with a 3-month follow-up. The fifth article ''Aesthetic rehabilitation of a case of polydiastema in the upper anterior region with direct composite restoration using the injection molding technique: case report" is a case report. In this case report, restoration of an anterior polydiastema case with direct flowable composite resin is described. Finally, the sixth article,'' Lingual frenulum surgery in the treatment of ankyloglossia: case series" is a case report. The aim of this case series is to evaluate the clinical outcomes of lingual frenectomy in two young adult female patients with ankyloglossia and to emphasise the impact of surgical intervention on speech ability, tongue mobility and overall oral function.

I would like to thank the authors, reviewers, editorial team and publisher for their hard work and dedication in bringing this issue to fruition. We look forward to providing you with the latest insights and developments in dentistry, and we welcome your feedback and suggestions.

Sincerely,

Assoc. Prof. Elif Pınar BAKIR, PhD
Editor-in-Chief

Journal of
Dental Sciences
and Education

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Journal of Dental Sciences and Education

Original Article

DOI: 10.51271/JDSE-0046

A bibliometric analysis of the literature on the use of artificial intelligence in pediatric dentistry

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ABSTRACT

Aims: This study aims to conduct a bibliometric analysis of the scientific literature on the use of artificial intelligence (AI) in pediatric dentistry to evaluate publication trends, citation impact, key contributors, and research themes.

Methods: A comprehensive literature search was conducted in the Web of Science (WoS) database up to February 8, 2025. The search included AI-related terms combined with pediatric dentistry keywords. A total of 78 relevant articles were identified and analyzed. VOSviewer software was used for bibliometric mapping, including co-authorship, co-citation, and keyword analysis.

Results: The number of publications on AI in pediatric dentistry has increased significantly since 2020, peaking in 2024, followed by a decline in 2025. The analysis identified key research topics, including diagnostic imaging, early childhood caries detection, dental age estimation, and orthodontic assessments. Despite the growth in research output, AI applications in pediatric dentistry remain significantly underdeveloped compared to other dental fields. Citation impact was relatively low, with the most referenced article receiving 83 citations.

Conclusion: AI is gaining attention in pediatric dentistry; however, its adoption is still in the early stages. Further research is needed to validate AI models, enhance clinical integration, and expand interdisciplinary collaboration. Addressing data limitations and improving real-world applicability will be crucial for AI's long-term impact on pediatric dental care.

Keywords: Artificial intelligence, deep learning, bibliometrics, pediatric dentistry

INTRODUCTION

The concept of artificial intelligence (AI) was first introduced in 1956, using the term to refer to technology designed to replicate human behavior.[1] Since then, the field has had substantial improvement and growth.[2] The emergence of AI has initiated a transformative period in medicine and dentistry. AI possesses the capacity to fundamentally alter the methodologies employed by dental practitioners in patient care, serving as a revolutionary instrument within the discipline.[3]

A prominent characteristic of AI is its ability to process and interpret extensive volumes of data at an extraordinary speed. numerous recent research have evaluated the effectiveness of AI in pediatric dentistry. These include dental plaque, assessing children's oral health, mesiodens and supernumerary tooth identification, early childhood caries, fissure sealant categorization, chronological age assessment in kids and adolescents using neural modeling, detecting deciduous and young permanent tooth, ectopic eruption of first permanent molar.[4] Scientific research indicate that AI can enhance dental care standards, improve diagnostic accuracy and efficacy, generate superior treatment graphics, model outcomes, and forecast oral diseases and health conditions.[4-7] AI models have garnered attention for their role as supplementary tools, enhancing the precision and accuracy of diagnosis. AI technology has been extensively utilized in medical sciences, exhibiting exceptional efficacy in many patient care activities, including disease diagnosis and risk assessment for disease development, among others.[8-10]

The incorporation of AI in pediatric dentistry is an anticipated trend, considering the swift technological advancements in this field. A bibliometric analysis is necessary to thoroughly examine the publication features of academic work focused on AI in pediatric dentistry. This research will facilitate a thorough grasp of the publication environment and citation trends. A bibliometric analysis is an efficient approach for the systematic evaluation of the quantity, quality, and importance of research output in a certain subject area.[11] To the best of our knowledge, no studies have been conducted on this topic. The primary aim of this study is to develop a detailed profile of the research on the application of AI in the field of pediatric dentistry. This will furnish researchers, physicians, and other stakeholders with essential insights and information. This will

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enable the identification of critical research areas and industry trends, therefore promoting the creation of more targeted and effective AI-based interventions and enhancing the quality of care for kids receiving pediatric dentistry.

METHODS

This study is a bibliometric analysis based on publicly available scientific literature and does not involve human participants, clinical trials, patient data, or any interventions requiring ethical approval. Therefore, approval from an institutional review board (IRB) or ethics committee was not required for this research. In line with ethical research standards and the policies of the Journal of Dental Sciences and Education, this study adheres to the Declaration of Helsinki and international ethical guidelines for research integrity. Since no patient information, medical records, or experimental procedures were used, a clinical trial registration number is not applicable. All data analyzed in this study were obtained from the Web of Science (WoS) database, and no confidential or personally identifiable information was accessed, ensuring full compliance with data protection and research ethics policies.

In February 2025, a comprehensive literature search of the WoS database, established by the Institute for Scientific Information (ISI) and now maintained by Clarivate Analytics, was conducted. Prior to 8 February 2025, a screening process was conducted on published articles, and pilot searches were carried out with the objective of optimising the search strategy. The initial searches were broadened, resulting in the identification of 93 studies. The "all fields" option was employed to conduct the electronic search, which enables the retrieval of all searchable data. To ensure that no relevant publications were overlooked, our search was comprehensive, and manual sifting was employed to enhance the accuracy of the results.

As a result of these pilot searches, a total of 93 studies were found when ''artificial intelligen*'' OR ''deep learn*'' OR ''machine learn*'' OR ''convolutional neural network*'' OR ''CNN*'' OR ''recurrent neural network*'' OR ''RNN*'' OR ''fully Convolutional Network*'' OR ''FCN*'' OR ''artificial neural network*'' (all fields) and "pediatric dentist*" OR "paediatric dentist*" (all fields) was typed in the search bar to determine the publications to be included in the study. The document types "article," "proceeding paper," "review," and "early access" were selected by applying a filter to the chosen articles. The language of publication was stipulated to be English throughout the process of identification and analysis. Only those publications that were published in this language were considered for inclusion in the study. Following the filtering process, the articles were evaluated in terms of their suitability for the subject matter. Initially, this was done according to the titles and abstracts of the articles. In cases where a decision could not be reached based on these criteria, the full text of the study was opened and examined by a single author. The selected articles were saved in a marked list. After the completion of all screening processes, a total of 78 studies were selected. The VOSviewer software (developed by Leiden University's Centre for Science and Technology Studies) were employed in this analysis for the purposes of bibliometric investigation and data visualisation.

The VOSviewer enables the production of maps of authors or journals based on co-citation data, as well as maps of keywords based on co-occurrence data. The software provides an extensive viewer for the detailed examination of bibliometric maps.[12] On 8 February 2025, the version 1.6.20 of the software VOSviewer was downloaded free of charge from the official website. The data in the '.txt' format, which was exported by creating a marked list, was opened with Microsoft Excel (Microsoft, Inc., Redmond, Washington) and the data set was edited to prevent the programme from misreading due to errors in the data set. In the author section, the names 'Çelik, Özer' and 'Celik, Ozer' are written in two different ways, and the programme identifies these as three distinct authors. A number of such errors in nomenclature were corrected in order to prevent erroneous interpretations. In order to identify the discrepancies between the authors, the author information in the WoS was initially examined. When the desired information was not found, the author data in Scopus was then consulted. If this information was also unavailable, a search was conducted on the internet. In the countries section, the spelling errors "Turkey" and "Turkiye" were corrected, despite the fact that they refer to the same country. Following the rectification of these inaccuracies, the data were exported in a '.txt' format using Microsoft Excel and processed in the VOSviewer program, resulting in the generation of visual representations.

The Microsoft Excel program was employed for the purpose of data tabulation.

In accordance with the ethical standards governing research, no approval was required, as the study did not involve clinical studies or the use of patient data. That is why clinical trial number is not applicable.

RESULTS

Growth in Publications

A total of 78 articles were obtained for review concerning the application of AI in pediatric dentistry. The analysis of publication trends and citation impact over time reveals a dynamic growth pattern in the application of AI within pediatric dentistry. The data indicates a notable increase in research output beginning in 2020, with a steady rise in both the number of publications and citations up to 2023, suggesting a growing academic and clinical interest in AI-driven innovations within the field. The peak year for publications and citations is 2024, where both metrics reach their highest values, potentially reflecting a culmination of advancements in AI methodologies, increased funding, and interdisciplinary collaborations within pediatric dentistry research. The substantial number of citations in 2024 further signifies the relevance and impact of recent publications, highlighting the recognition and adoption of AI-based approaches in the field. However, a sharp decline is observed in 2025 for both publications and citations, which may be attributed to several factors, including data incompleteness for 2025, as the year is still ongoing; a potential plateau in research interest, indicating a shift in focus toward more specialized applications of AI; and publication lag effects, where ongoing research has not yet been indexed or cited (**Figure 1**).

Countries/Regions and Institutions

A total of 30 countries or regions published at least one article on the topic of AI in pediatric dentistry between the years 2017 and 2025. The United States of America has published the greatest number of articles on the subject, with 17 articles,

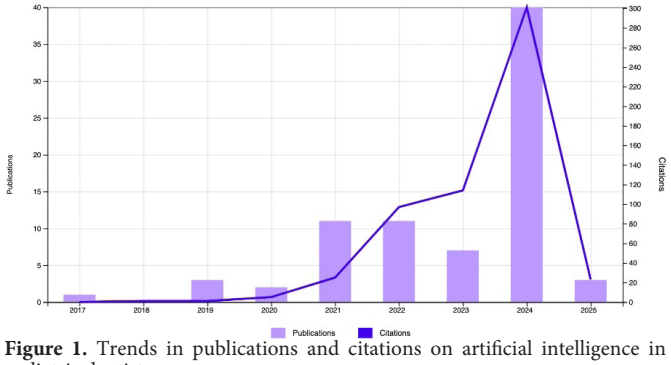


Figure 1. Trends in publications and citations on artificial intelligence in pediatric dentistry

followed by Turkey and China, which have published 13 and 12 articles, respectively. Moreover, these countries were the recipients of the greatest number of citations. A collaboration map of countries on this subject, together with a list of the five most prolific countries, is provided in **Figure 2A, B**. In terms of institutional affiliations, there were notable examples of robust collaborative relationships, including those with Eskişehir Osmangazi University and Ankara University (**Figure 3A**). The University of Alabama Birmingham published the greatest number of papers, with a total of 6, followed by Osaka University and Sichuan University, which published 5 and 5 papers, respectively. With regard to the analysis of citation figures, Ankara University and the Peking University were the most highly cited universities, with respective figures of 137 and 84. The top five most prolific institutions are represented in **Figure 3B**.

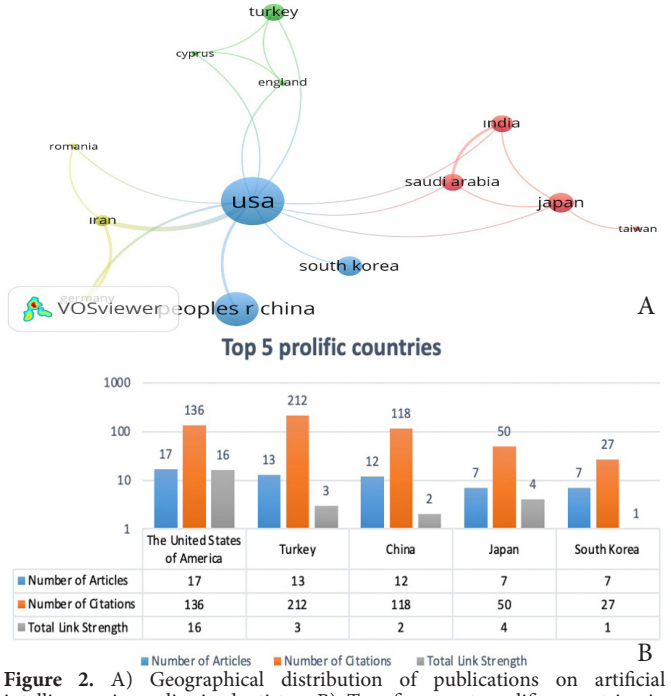


Figure 2. A) Geographical distribution of publications on artificial intelligence in pediatric dentistry, B) Top five most prolific countries in artificial intelligence research in pediatric dentistry

Authors

The author profiles extracted from the publications were subjected to analysis with the aim of identifying the most influential scholars in the field of AI in pediatric dentistry. The seven most prolific authors according to article numbers, and citation numbers are presented in **Figure 4A**, **B**, respectively. With regard to the attention paid to their work by other authors, Orhan, Kaan; Xia, Bin; and Hao, Aimin, have had the most significant impact on this field, having been cited 137,

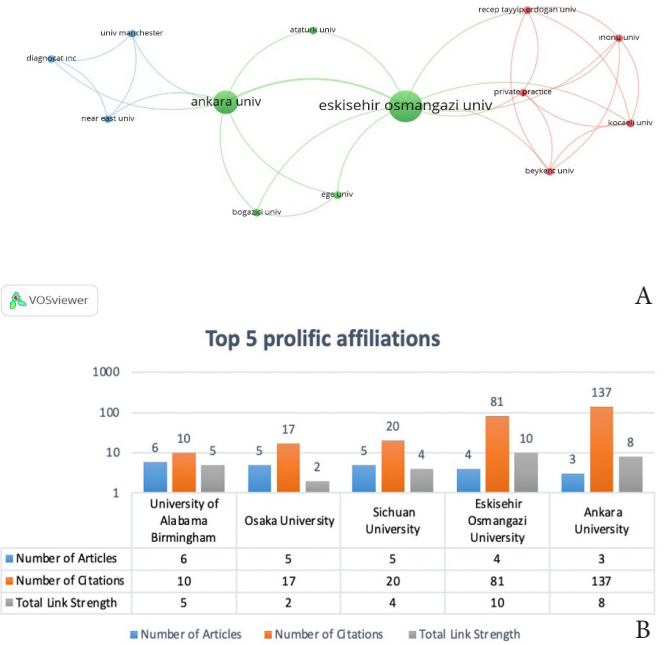


Figure 3. A) Affiliation collaboration network in artificial intelligence research in pediatric dentistry, B) Top five most prolific affiliations in artificial intelligence research in pediatric dentistry

84, and 82 times, respectively. The findings suggest that the majority of collaborating authors were from the same country or region. A notable degree of collaboration in **Figure 4C** was evident between the following research teams: Celik Ozer, Bayrakdar Ibrahim Sevki, Orhan Kaan, Bilgir Elif, and Kilic Munevver Coruh.

Figure 4. A) Most 7 prolific authors based on the number of publications, B) Most cited 5 authors in artificial intelligence research in pediatric dentistry, C) Co-authorship network in artificial intelligence research in pediatric dentistry

Articles

The most highly cited publications provide readers with a comprehensive overview of the development and current status of a field of study, offering guidance to subsequent investigators and influencing the direction of ongoing research. **Table** presents the 10 most frequently cited papers in this context.

Journals

Figure 5 depicts the five most prolific journals, as determined by the number of publications and citations. The three journals with the highest number of publications were Journal of Clinical Pediatric Dentistry, International Journal of Paediatric Dentistry, and BMC Oral Health, with respective publication numbers of 11, 8, and 6. With regard to the number of citations, the most influential journals were BMC Oral Health, Scientific Reports, and Journal of Clinical Pediatric Dentistry, with 90, 75, and 71 citations, respectively.

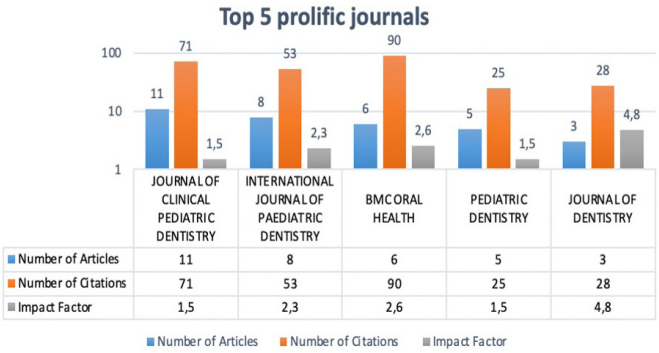


Figure 5. Top five most prolific journals publishing artificial intelligence research in pediatric dentistry

Co-Citation References

A co-citation references network is a network comprising nodes representing documents and edges indicating the co-citation relationships between these documents in the context of bibliometric analysis. The term "co-citation" is used to describe the occurrence of two texts being cited together by one or more later documents. The application of co-citation analysis enables the identification of interdisciplinary connections, the discovery of pivotal publications, and the elucidation of the structural and developmental nuances of scientific domains. **Figure 6** presents an illustrative co-citation references network map of references mentioned at least ten times.

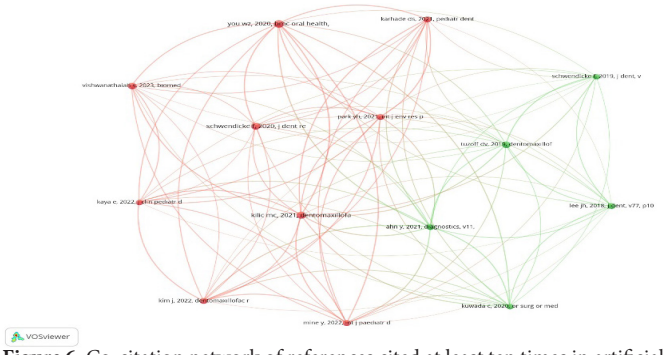


Figure 6. Co-citation network of references cited at least ten times in artificial intelligence research in pediatric dentistry

Keywords

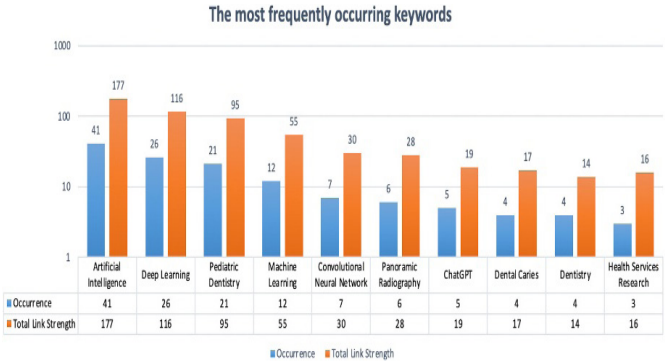
The most frequently occurring keywords were "artificial intelligence," "deep learning," "pediatric dentistry," "machine learning," "convolutional neural network," "panoramic

Table. Most cited 10 articles

Title	Author	Sources	Publication year	Total citations	Type of study
Deep learning-based dental plaque detection on primary teeth: a comparison with clinical assessments	You WZ, Hao AM, LI S, Wang Y, Xia B	BMC Oral Health	2020	82	Article
Clinically applicable artificial intelligence system for dental diagnosis with CBCT	Ezhov M, Gusarev M, Golitsyna M, Yates JM, Kushnerev, E, Tamimi D, Aksoy S, Shumilov E, Sanders A, Orhan K	Scientific Reports	2021	75	Article
Artificial intelligence system for automatic deciduous tooth detection and numbering in panoramic radiographs	Kılıc MC, Bayrakdar IS, Celik O, Bılgır, E, Orhan K, Aydın OB, Kaplan FA, Saglam H, Odabas A, Aslan AF, Yilmaz AB	Dentomaxillofacial Radiology	2021	58	Article
Artificial intelligence its uses and application in pediatric dentistry: a review	Vishwanathaiah S, Fageeh HN, Khanagar SB, Maganur PC	Biomedicines	2023	34	Review
Detecting the presence of supernumerary teeth during the early mixed dentition stage using deep learning algorithms: a pilot study	Mine Y, Iwamoto Y, Okazaki S, Nakamura K, Takeda S, Peng TY, Mitsuhata C, Kakimoto N, Kozai K, Murayama T	International Journal of Paediatric Dentistry	2022	33	Article
Proposing a CNN method for primary and permanent tooth detection and enumeration on pediatric dental radiographs	Kaya E, Gunec HG, Gokyay SS, Kutal S, Gulum S, Ates HF	Journal of Clinical Pediatric Dentistry	2022	31	Article
An automated machine learning classifier for early childhood caries	Karhade DS, Roach J, Shrestha P, Simancas-Pallares MA, Ginnis J, Burk ZJS, Ribeiro AA, Cho HY, Wu D, Divaris K	Pediatric Dentistry	2021	24	Article
Deep learning neural modelling as a precise method in the assessment of the chronological age of children and adolescents using tooth and bone parameters	Zaborowicz M, Zaborowicz K, Biedziak B, Garbowski T	Sensors	2022	19	Article
Artificial intelligence-aided detection of ectopic eruption of maxillary first molars based on panoramic radiographs	Liu JL, Liu Y, Li SH, Ying SC, Zheng LW, Zhao ZH	Journal of Dentistry	2022	18	Article
A pilot study of a deep learning approach to submerged primary tooth classification and detection	Caliskan S, Tuloglu N, Celik O, Ozdemir C, Kizilaslan S, Bayrak S	International Journal of Computerized Dentistry	2021	18	Article

CBCT: Cone beam computed tomography, CNN: Convolutional neural network

radiography," "ChatGPT," "dental caries," "dentistry," and "health services research" (**Figure 7**). The results revealed that artificial intelligence exhibited the highest occurrence and total link strength. In light of the recent proliferation of publications on the subject of artificial intelligence in pediatric dentistry, particularly in the period following 2019, we present in **Figure 8** a map of the co-occurrence network of keywords used on this topic.



	Artificial Intelligence	Deep Learning	Pediatric Dentistry	Machine Learning	Convolutional Neural Network	Panoramic Radiography	ChatGPT	Dental Caries	Dentistry	Health Services Research
Occurrence	41	26	21	12	7	6	5	4	4	3
Total Link Strength	177	116	95	55	30	28	19	17	14	16

Figure 7. Keyword co-occurrence network in artificial intelligence research in pediatric dentistry

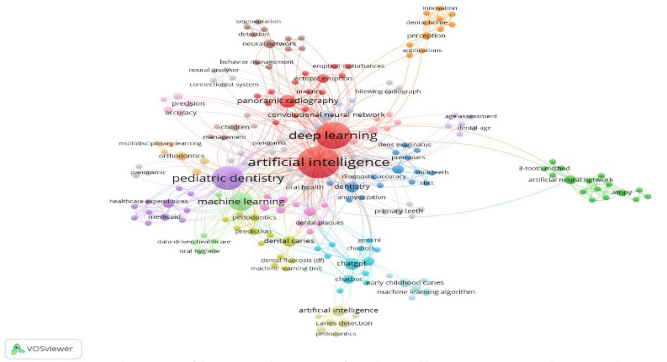


Figure 8. Evolution of keywords in artificial intelligence research in pediatric dentistry over time

DISCUSSION

AI is generally characterized as "a system's capacity to accurately interpret external data, learn from it, and utilize these insights to adapt flexibly and accomplish specific tasks and goals". The substantial enhancement in processing power over the last fifty years, along with the proliferation of large data, has advanced AI applications into novel domains. AI is already prevalent in our daily lives via gadgets such as cellphones and automobiles. It is currently achieving substantial progress in the realm of medicine. The swift progress in computer technology over the last two decades complicates the forecasting of AI's future significance in medicine. Nonetheless, given present uses, it is probable that physicians and AI will collaborate closely in the imminent future[9]. The most significant roles of AI in pediatric dentistry: AI systems, particularly deep learning algorithms, can be applied to areas such as dental plaque detection,[13] dental diagnosis with 3D imaging,[14] tooth detection and numbering,[15] the assessment of chronological age,[16] the detection of ectopic eruption,[17] the classification of submerged primary teeth,[18] the tooth germ detection,[19] clinical guidance, remote care, clinical documentation, and prediction of treatment outcomes.

The findings of this bibliometric analysis highlight the increasing academic and clinical interest in the application of AI in pediatric dentistry. The steady growth in publications and citations from 2020 to 2024 reflects the expanding role of AI technologies in various aspects of pediatric dental care, including diagnosis, treatment planning, and disease prediction.[20] This trend aligns with the broader integration of AI in healthcare, where machine learning algorithms and deep learning models are increasingly leveraged to enhance diagnostic accuracy, optimize treatment efficiency, and improve patient outcomes.

The peak in both publication output and citation count in 2024 suggests a pivotal moment in AI research within pediatric dentistry. This surge may be attributed to advancements in AI methodologies, increased accessibility of computational tools, and interdisciplinary collaborations between dental researchers, computer scientists, and healthcare professionals. Additionally, the growing number of studies exploring AI applications, such as early childhood caries detection, dental age estimation, and orthodontic assessments, underscores the diverse capabilities of AI in pediatric dental care. The high citation count further signifies the influence and impact of recent publications, indicating that AI-driven approaches are gaining widespread recognition in the field.

Despite the upward trajectory, a notable decline in both publications and citations is observed in 2025. This trend may be attributed to multiple factors. First, as the year is still ongoing, data incompleteness could be influencing the observed decline. Second, research interest in AI applications may have reached a plateau, with scholars shifting their focus toward more specialized and refined AI models rather than broad exploratory studies. Third, publication lag effects could also play a role, as studies conducted in 2024 may not yet be published or cited extensively. Future bibliometric analyses should monitor whether this decline represents a temporary fluctuation or a longer-term shift in research trends.

The analysis of publications on AI in pediatric dentistry highlights distinct geographical and institutional trends, with contributions from only 30 countries or regions. This limited engagement suggests that the adoption of AI in pediatric dentistry remains insufficient, especially when compared to its application in other dental specialties such as orthodontics, prosthodontics, and maxillofacial surgery, where AI-driven research has seen significantly higher publication volumes. The United States, Turkiye, and China lead in research output on this topic, with 17, 13, and 12 publications, respectively. Their prominence can be attributed to substantial financial investments, strong government support, and strategic prioritization of AI-driven advancements in healthcare. The United States' leadership is driven by large-scale federal funding initiatives, extensive private sector investments, and strong integration of AI research within academic and clinical institutions. Likewise, Turkiye and China have allocated significant funding toward AI development, with direct government-backed research initiatives aimed at expanding AI applications in healthcare and dentistry.[21]

In terms of institutional contributions, the University of Alabama at Birmingham recorded the highest number of publications, with a total of six, followed by Osaka University and Sichuan University, each contributing five publications. An analysis of citation metrics revealed that Ankara University and Peking University were the most frequently cited institutions, with 137 and 84 citations, respectively.

The prominence of these universities highlights their strong research capabilities and commitment to advancing AI technologies in pediatric dentistry. However, the significantly lower number of publications on AI in pediatric dentistry compared to other dental disciplines underscores a major gap in research and clinical integration. This highlights the need for increased global investment, interdisciplinary collaboration, and broader international engagement to enhance AI's role in pediatric dental care and improve patient outcomes.

This bibliometric research identified the most frequently cited articles on the use of AI in pediatric dentistry. However, the citation impact remains relatively modest, with the most referenced article receiving only 83 citations, a figure significantly lower than those observed in other dental disciplines. This suggests that while AI is gaining attention in pediatric dentistry, its influence and research impact are still limited compared to its applications in fields such as orthodontics, prosthodontics, and maxillofacial surgery.

Limitations

While this bibliometric analysis provides valuable insights into the research landscape of AI in pediatric dentistry, certain limitations must be acknowledged. First, the study is based exclusively on data retrieved from the WoS database, potentially leading to the omission of relevant studies indexed in other databases such as Scopus, PubMed, or IEEE Xplore, which also contain AI-related dental research. Second, variations in keyword selection and search strategies may have influenced the scope of retrieved studies, as AI-related terminology continues to evolve, and some relevant works may not have been captured. Third, as a bibliometric study, this research focuses on quantitative publication trends and citation metrics rather than directly evaluating the clinical effectiveness or real-world applicability of AI-driven tools in pediatric dentistry. Future research should incorporate qualitative assessments, including clinical trials and expert opinions, to better understand the practical implications of AI in pediatric dental practice. Additionally, given the rapid advancements in AI technologies, continuous updates to bibliometric studies are necessary to track emerging innovations, shifting research trends, and evolving clinical applications over time.

CONCLUSION

This bibliometric analysis reveals that while the use of AI in pediatric dentistry has grown in recent years, it remains underdeveloped compared to other dental specialties. The relatively low number of publications and citations indicates that AI applications in this field are still in their early stages. Despite its potential to enhance diagnostics, treatment planning, and disease prediction, further research is needed to validate AI models, improve clinical integration, and expand interdisciplinary collaboration. Future studies should focus on addressing data limitations and real-world applicability to maximize AI's impact on pediatric dental care.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study is a bibliometric analysis based on publicly available sources and does not involve human or animal participants and therefore does not require ethical approval.

Informed Consent

Since this research is a bibliometric study, it did not require informed consent.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

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

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

Availability of data and materials

The data used and analyzed during the current study are available from the corresponding author on reasonable request.

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Endodontic treatment procedures applied by endodontists and general dentists in Turkiye: a questionnaire survey

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ABSTRACT

Aims: The aim of this study is to determine the use of rubber dams, magnification techniques, working length measurement methods, and preferences for multiple sessions among endodontists and general dental practitioners performing root canal treatment in Turkiye, as well as to evaluate disinfection and obturation protocols.

Methods: In this study, 167 dentists working in Turkiye were included, and they were asked to respond to a questionnaire consisting of 17 questions covering gender, the institution they work at, specialty, the years they have been practicing, and information related to the stages of root canal treatment. The data obtained from this study were analyzed using the chi-square test, Fisher's exact test, and Pearson chi-square test, based on the number of observations in the tables.

Results: Of the participants in the study, 53.89% reported attending any seminar/course related to endodontics after graduation. Additionally, 43.71% of the participants perform more than 30 root canal treatments per month. Notably, 91.02% of the participants typically perform root canal treatments on molar teeth. However, 77.25% of the participants do not use rubber dams during treatment, and 91.02% do not utilize magnification during root canal procedures. There is a statistically significant relationship between titles and the frequency of performing root canal treatments ($p<0.05$). Among the endodontists, 85.71% perform more than 30 root canal treatments per month, while 37.67% of general dental practitioners do the same; conversely, 18.49% of general dentists perform between 0-10 root canal treatments per month. Furthermore, there is a statistically significant relationship between titles and the use of rubber dams during root canal treatments ($p<0.05$). While 38.1% of endodontists and 82.88% of general dental practitioners do not use rubber dams during treatment, 14.29% of endodontists and 2.05% of general dentists always use rubber dams. Lastly, there is also a statistically significant relationship between titles and the utilization of magnification during treatment ($p<0.05$). While 76.19% of endodontists and 93.15% of general dental practitioners do not utilize magnification during treatment, 0.68% of general dentists occasionally use loupes or smartphone cameras for assistance.

Conclusion: As a result of this study, it was seen that general dentists have sufficient knowledge about root canal protocols and materials. It was also seen that endodontists have relatively more knowledge on this subject than general dentists.

Keywords: Endodontist, root canal treatment, general dental practitioners, education, dentistry

INTRODUCTION

Root canal treatment is a treatment method applied to eliminate pathogens in the canals and improve existing pathologies in order to prevent early tooth loss.[1] Although the success rate of root canal treatment is high, the application of the treatment requires a certain level of knowledge, necessary materials and time.[2]

Rubber dam, which has been used for 150 years for isolating the tooth during root canal treatment, is still considered the most ideal method for isolation.[3] According to Silversin et al.,[4] all endodontic applications should be performed under rubber dam isolation and rubber dam application should be accepted as the gold standard. In addition to providing adequate oropharyngeal protection, rubber dam isolation should be used for infection control and the success of root canal treatment.[5]

Determination of working length is one of the most critical steps in root canal treatment and a clear understanding of the morphology of the root canal system including the root apex is essential. Apical constriction has been proposed as an ideal apical termination for root canal preparation. It is the part of the canal with the smallest diameter and any violation of this area is not recommended for long-term, successful results.[6,7] Determination of working length is done by different methods. These methods include finger sensitivity, electronic apex locator (EAL), radiographic method and moisture in paper cones, cone beam computed tomography (CBCT).[8]

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Endodontics is limited to a narrow field of study because it deals with very small anatomies. Over the years, many magnifying devices have been introduced as tools that bridge the gap between the naked eye and the microscope. Today, tools such as endoscopes, magnifying glasses (loupes) and intraoral cameras have largely been replaced by more practical and convenient devices for practice such as magnifying glasses (loupes) and operating microscopes.[9,10]

Technological and methodological changes aimed at improving endodontic treatment outcomes can be categorized into two main areas. One area of technological advancement has been root canal preparation itself, accompanied by the advancement of appropriate instrumentation, from stainless steel hand files[11] to rotary nickel-titanium multi-file systems[12] and alternative machine-driven single-file systems.[13]

Since microorganisms are difficult to eradicate from infected root canals, a number of methods have been used to reduce their numbers, including various instrumentation techniques, irrigation regimens, and intracanal medicaments.[14,15]

Since stainless steel hand files have been the preferred method for many years, there are data on the long-term results of endodontic treatment.[16,17] After NiTi alloys, the popularity of reciprocating motion systems has increased. This development indicates that the instruments require five rotations to complete a full 360° rotation. At the same time, the elastic limit of the instrument is not exceeded due to this movement.[18] Studies suggest the use of NiTi alloys with endodontic motors by taking advantage of their mechanical properties such as superelasticity and shape memory.[19-21]

Some of the irrigation solutions used in root canal treatment are: sodium hypochlorite (NaOCl), ethylenediamine tetraacetic acid (EDTA), chlorhexidine (CHX), distilled water, physiological serum, ozonated water, citric acid.[22]

Another area of progress is characterized by the establishment of effective intracanal disinfection protocols, from syringe irrigation with NaOCl to passive ultrasonic irrigation (PUI).[23] Traditional syringe irrigation is a widely accepted technique. Traditional syringe irrigation technique may fail to effectively deliver and distribute irrigants in the root canal system, especially in the apical third and isthmus regions.[24] Activation in root canal irrigation is the process of using mechanical, physical or other forms of energy to increase the effectiveness of irrigants within the root canal system. Currently, there are automated systems and manual methods for irrigation activation. Among the different activation methods, manual dynamic activation (MDA), PUI and sonic irrigation (SI) are some of the most widely used and studied methods.[25] The null hypothesis was that there is no difference in the path followed by endodontists and general dentists in root canal treatment. The aim of this study was to determine the rubber dam, magnification use, working length detection method and multi-session preference of endodontists and general dental practitioners performing root canal treatment in Turkiye, and also to evaluate disinfection and obturation protocols.

METHODS

Ethics committee approval was given by the Dicle University Faculty of Dentistry Ethics Committee (Date: 29.01.2020, Decision No: 2020-2). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

The survey questions were prepared on an internet platform (Google forms) that provides survey services. The link that provides access to the survey form was shared only on various social platforms where dentists are present between March 2023 and April 2023. The responses of 167 people who completed all the questions of the survey were included in the study. Incomplete surveys were not included in the study. A total of 167 people, 21 endodontists and 146 general dental practitioners working in Turkiye, participated in this study. Participation in the survey is voluntary. **Table 1** shows the survey questions presented to participants.

Statistical Analysis

The data obtained in this study were analyzed with SPSS software version 21 (IBM SPSS Inc., Armonk, NY, USA) package program. Descriptive statistics are stated in the form of frequency and percentage [n (%)]. Chi-square analysis was applied to nominal variables, Fisher's exact test was applied to 2x2 tables and Pearson chi-square analysis was applied to RxC tables with the help of Monte Carlo simulation. Since 20% of the expected value in the cells was less than 5, chi-square analysis was performed with the help of Monte Carlo simulation. The significance level was determined as $p<0.05$.

RESULTS

167 dentists who participated in our survey answered the questions. Of the 167 people, 21 (12.57%) were endodontists and 146 (87.43%) were general dental practitioners. 47.9% of the participating dentists worked in private clinics, 34.13% in ODHC, and 17.96% in university hospitals. In the study, 51.5% had worked for 0-5 years, 20.96% for 6-10 years, 11.38% for 11-15 years, and 16.17% for over 16 years, and 53.89% of these dentists had attended any seminar/course related to endodontics after graduation (**Table 2**).

43.71% of the participants reported that they performed more than 30 root canal treatments per month and 91.02% of the dentists usually performed root canal treatments on molar group teeth. 77.25% of the participants reported that they did not use rubber dams during treatment, 91.02% did not use magnification during treatment, 56.89% did not use gel-type lubricants during treatment, and 74.25% did not use activation techniques during irrigation. Of those who used activation techniques during irrigation, 41.86% reported that they used PUI activation techniques during irrigation.

62.28% of the participants reported using the radiography+EAL technique to determine working length, 88.02% reported using NiTi rotary files in routine root canal treatment, 95.81% used NaOCl/diluted NaOCl as an irrigation solution, 52.1% employed the lateral condensation filling technique, 43.11% used epoxy resin-based canal filling, and 82.63% preferred composite filling restoration after endodontic treatment. Additionally, 52.69% of dentists stated they completed root canal treatment in a single session, while 47.31% completed it in multiple sessions. Among those who completed root canal treatment in multiple sessions, 97.44% indicated they used CaOH as an intra-canal medicament (**Table 3**).

There is a statistically significant relationship between titles (endodontist and general dental practitioners) and the institutions they work in ($p<0.05$). While 23.81% of endodontists and 51.37% of general dental practitioners

Table 1. Survey questions
In which type of institution do you work?
Private clinic
Oral and dental health center
University hospital
What is your title?
Endodontists
General dental practitioners
How many years have you been working as a dentist?
1-5 years
6-10 years
11-15 years
16+ years
Have you attended any seminars/courses related to endodontics after graduation?
Yes
No
How often do you perform endodontic treatment?
1-10 per month
11-20 per month
21-30 per month
31 or more per month
Which group of teeth do you mostly treat?
Incisors
Premolar teeth
Molar teeth
Do you use rubber dam when performing root canal treatment?
Always
Most of the time
Sometimes
I don't use it
Do you use magnification when performing root canal treatment?
No
Loupe
Dental microscope
Other….
How do you determine the working length in root canal treatment?
With radiography
With an electronic apex locator
With radiography and an electronic apex locator
What files do you use in routine root canal treatment?
K type file
H type file
Ni Ti hand files
Ni Ti rotary files
Which of the following do you use as an irrigation agent while performing root canal treatment?
NaOCl
EDTA
Chlorhexidine
Other….
Which activation technique do you use during irrigation?
I do not use
Endoactivator
Passive ultrasonic irrigation
Other…
How many sessions do you complete for root canal treatment?
Single session
Multiple sessions
If you perform multiple-session root canal treatment, which intra-canal medicament do you use between sessions?
CaOH
Two-component antibiotic paste
Three-component antibiotic paste
Other…
Which filling technique do you use?
Single cone technique
Lateral condensation
Hot vertical condensation
Hot lateral condensation
Continuous heat obturation
Which restoration do you prefer after endodontic treatment?
Composite filling
Amalgam filling
Crown
Which canal filling material do you use?
Epoxy resin-based canal filling
Bioceramic-based canal filling
Calcium hydroxide-containing canal filling
Zinc oxide eugenol-containing canal filling

EDTA: Etilendiamine tetraaceticacid

Table 2. Frequency distribution table			
		n	%
In which type of institution do you work?	Private clinic	80	47.9
	Oral and dental health center	57	34.13
	University hospital	30	17.96
	Total	167	100
What is your title?	Endodontist	21	12.57
	General dental practitioners	146	87.43
	Total	167	100
How many years have you been working as a dentist?	0-5	86	51.5
	6-10	35	20.96
	11-15	19	11.38
	16<	27	16.17
	Total	167	100
Have you attended any seminars/ courses related to endodontics after graduation?	Yes	90	53.89
	No	77	46.11
	Total	167	100
How often do you perform endodontic treatment? (per month)	0-10	27	16.17
	11-20	39	23.35
	21-30	28	16.77
	30<	73	43.71
	Total	167	100
Which group of teeth do you mostly treat?*	Incisors	69	41.32
	Premolar teeth	81	48.50
	Molar teeth	152	91.02
Do you use rubber dam when performing root canal treatment?	Always	6	3.59
	Most of the time	7	4.19
	Sometimes	25	14.97
	I don't use it	129	77.25
	Total	167	100
Do you use magnification when performing root canal treatment?	No	152	91.02
	Loupe	12	7.19
	Dental microscope	2	1.2
	Sometimes a magnifying glass, a phone camera	1	0.6
	Total	167	100
How do you determine the working length in root canal treatment?	With radiography	35	20.96
	With an electronic apex locator	28	16.77
	With radiography and an electronic apex locator	104	62.28
	Total	167	100
What files do you use in routine root canal treatment?*	K type file	104	62.28
	H type file	75	44.91
	Ni Ti hand files	32	19.16
	Ni Ti rotary files	147	88.02
Do you use gel type lubricant during the procedure?	Yes	72	43.11
	No	95	56.89
	Total	167	100
Which of the following do you use as an irrigation agent while performing root canal treatment?*	NaOCl	160	95.81
	EDTA	109	65.27
	CHX	91	54.49
	Distilled water	12	7.19
	Physiological saline	20	11.98
	Oseptin/octenidine	3	1.80
	Ethyl alcohol	1	0.60
	Hydrogen peroxide/H2O2	3	1.80
Do you use activation techniques during the irrigation process?	Yes	43	25.75
	No	124	74.25
	Total	167	100
Which activation technique do you use during irrigation?	Endoactivator	11	25.58
	Irrigating with a syringe	1	2.33
	Gutta percha activation	9	20.93
	Lentulo	1	2.33
	Manual dynamic activation	2	4.65
	Heated NaOCl	1	2.33
	Passive ultrasonic irrigation	18	41.86
	Total	43	100
How many sessions do you complete for root canal treatment?	Single session	88	52.69
	Multiple session	79	47.31
	Total	167	100
If you perform multiple-session root canal treatment, which intra-canal medicament do you use between sessions?	Two-component antibiotic paste	1	1.28
	Phenol	1	1.28
	CaOH	76	97.44
	Total	78	100
Which filling technique do you use?	Single cone technique	78	46.71
	Lateral condensation	87	52.1
	Hot filling technique	2	1.2
	Total	167	100
Which restoration do you prefer after endodontic treatment?	Amalgam filling	14	8.38
	Composite filling	138	82.63
	Crown	15	8.98
	Total	167	100
Which canal filling material do you use?	Bioceramic-based canal filling	19	11.38
	Zinc oxide eugenol-containing canal filling	12	7.19
	Epoxy resin-based canal filling	72	43.11
	Calcium Hydroxide-containing canal filling	64	38.32
	Total	167	100

*Multiple answer options have been selected, EDTA: Etilendiamine tetraaceticacid

Table 3. Chi-square test results regarding the relationship between titles and demographic information

		Title						Chi-square test	
		Endodontist		General dental practitioners		Total			
		n	%	n	%	n	%	Chi-square	p
In which type of institution do you work?	Private clinic	5	23.81	75	51.37	80	47.9	38.889	0.001
	Oral and dental health center	2	9.52	55	37.67	57	34.13		
	University hospital	14	66.67	16	10.96	30	17.96		
	Total	21	100	146	100	167	100		
How many years have you been working as a dentist?	0-5	10	47.62	76	52.05	86	51.5	*	0.567
	6-10	5	23.81	30	20.55	35	20.96		
	11-15	4	19.05	15	10.27	19	11.38		
	16<	2	9.52	25	17.12	27	16.17		
	Total	21	100	146	100	167	100		
Have you attended any seminars/courses related to endodontics after graduation?	Yes	13	61.9	77	52.74	90	53.89	0.307	0.58
	No	8	38.1	69	47.26	77	46.11		
	Total	21	100	146	100	167	100		

work in private clinics, 66.67% of endodontists and 10.96% of general dental practitioners work in university hospitals.

There is no statistically significant relationship between titles and years of practice, participation in any seminar/course related to endodontics after graduation, groups of teeth receiving root canal treatment, techniques used to determine working length, files used in routine root canal treatment, irrigation solutions used, use of activation techniques during irrigation, use of gel-type lubricants during treatment, filling techniques employed, canal filling materials used, intra-canal medicaments used between sessions in multiple-session root canal treatments, and preferred restorations after endodontic treatment ($p>0.05$).

There is a statistically significant relationship between titles and the frequency of performing root canal treatments ($p<0.05$). While 85.71% of endodontists and 37.67% of general dental practitioners perform more than 30 root canal treatments per month, 18.49% of general dental practitioners perform between 0-10 root canal treatments per month.

Additionally, there is a statistically significant relationship between titles and the use of rubber dam during treatment ($p<0.05$). While 38.1% of endodontists and 82.88% of general dental practitioners do not use rubber dam during treatment, 14.29% of endodontists and 2.05% of general dental practitioners always use rubber dam during treatment.

There is a statistically significant relationship between titles and the use of magnification during procedures ($p<0.05$). While 76.19% of endodontists and 93.15% of general dental practitioners do not use magnification during treatment, 0.68% of general dental practitioners sometimes use a magnifying glass or phone camera during treatment.

Additionally, there is a statistically significant relationship between titles and the number of sessions required to complete root canal treatment ($p<0.05$). While 80.95% of endodontists and 48.63% of general dental practitioners complete root canal treatment in a single session, 19.05% of endodontists and 51.37% of general dental practitioners complete it in multiple sessions (**Table 4**).

DISCUSSION

Root canal treatment is a proven procedure, but many factors can affect its success. In our country, the number of endodontic specialists is steadily increasing, and technological advancements are leading to the development of various procedures for the application of root canal treatment.

In the study conducted by Ünal et al.,[26] the average number of root canal treatments performed by participating dentists in a month was examined. The study also indicated that dental practice in our country is predominantly carried out by general dental practitioners, particularly due to the insufficient number of endodontists, resulting in endodontic treatments being performed by dentists working in both the public and private sectors. In the study by Ferreira et al.,[27] it was reported that the number of endodontic treatments per month (82%) of endodontists was more than 11. 43.71% of the participants in our study performed more than 30 root canal treatments per month. There was a statistically significant relationship between the titles (endodontists and general practitioners) and the frequency of performing root canal treatments. While 85.71% of endodontists and 37.67% of general dental practitioners performed more than 30 root canal treatments per month, 18.49% of general dental practitioners performed 0-10 root canal treatments per month. There was a statistically significant relationship between the titles and the institutions they worked at. While 23.81% of endodontists and 51.37% of general dental practitioners worked in private clinics, 66.67% of endodontists and 10.96% of general dental practitioners worked in university hospitals. We believe that the reason for this is the increasing number of new universities and dental faculties in our country.

In a survey study conducted by Dindar et al.,[28] it was found that dentists more frequently treat molar teeth (77.96%) in their routine endodontic practice. The frequency of treating molar teeth among dentists with more than 16 years of professional experience was significantly lower compared to those with 1-5 years and 6-15 years of experience. In our study, 91.02% of the participating dentists reported that they typically perform root canal treatment on molar group teeth. Additionally, there is no statistically significant relationship between titles and years of practice. In a study conducted by Ünlü et al.,[29] it was reported that preventive dentistry has not been fully established in our country and that molar teeth tend to decay within a few years after eruption. We believe that this rate is high because permanent molars are the first teeth to erupt in the mouth and preventive dentistry is not widespread in our country.

Table 4. Chi-square test results regarding the relationship between titles and other parameters

		Title						Chi-square test	
		Endodontist		General dental practitioners		Total			
		n	%	n	%	n	%	Chi-square	p
How often do you perform endodontic treatment? (per month)	0-10	0	0	27	18.49	27	16.17	*	0.001
	11-20	0	0	39	26.71	39	23.35		
	21-30	3	14.29	25	17.12	28	16.77		
	30<	18	85.71	55	37.67	73	43.71		
	Total	21	100	146	100	167	100		
Which group of teeth do you mostly treat?	Molar teeth	21	100	131	89.73	152	91.02	Fisher's exact	0.221
	Other	0	0	15	10.27	15	8.98		
	Total	21	100	146	100	167	100		
Do you use rubber dam when performing root canal treatment?	Always	3	14.29	3	2.05	6	3.59	*	0.001
	Most of the time	1	4.76	6	4.11	7	4.19		
	Sometimes	9	42.86	16	10.96	25	14.97		
	I don't use it	8	38.1	121	82.88	129	77.25		
	Total	21	100	146	100	167	100		
Do you use magnification when performing root canal treatment?	No	16	76.19	136	93.15	152	91.02	*	0.006
	Loupe	3	14.29	9	6.16	12	7.19		
	Dental microscope	2	9.52	0	0	2	1.2		
	Sometimes a magnifying glass, a phone camera	0	0	1	0.68	1	0.6		
	Total	21	100	146	100	167	100		
How do you determine the working length in root canal treatment?	With radiography	2	9.52	33	22.6	35	20.96	*	0.187
	With an electronic apex locator	6	28.57	22	15.07	28	16.77		
	With radiography and an electronic apex locator	13	61.9	91	62.33	104	62.28		
	Total	21	100	146	100	167	100		
What files do you use in routine root canal treatment?	Ni Ti rotary files	20	95.24	127	86.99	147	88.02	Fisher's exact	0.474
	Other	1	4.76	19	13.01	20	11.98		
	Total	21	100	146	100	167	100		
Do you use gel type lubricant during the procedure?	Yes	6	28.57	66	45.21	72	43.11	1.449	0.229
	No	15	71.43	80	54.79	95	56.89		
	Total	21	100	146	100	167	100		
Which of the following do you use as an irrigation agent while performing root canal treatment?	NaOCl/diluted NaOCl	21	100	139	95.21	160	95.81	Fisher's exact	0.598
	Other	0	0	7	4.79	7	4.19		
	Total	21	100	146	100	167	100		
Do you use activation techniques during the irrigation process?	Yes	9	42.86	34	23.29	43	25.75	2.725	0.099
	No	12	57.14	112	76.71	124	74.25		
	Total	21	100	146	100	167	100		
Which activation technique do you use during irrigation?	Endoactivator	3	33.33	8	23.53	11	25.58	*	0.99
	Irrigating with a syringe	0	0	1	2.94	1	2.33		
	Gutta percha activation	2	22.22	7	20.59	9	20.93		
	Lentulo	0	0	1	2.94	1	2.33		
	Manual dynamic activation	0	0	2	5.88	2	4.65		
	Heated NaOCl	0	0	1	2.94	1	2.33		
	Passive ultrasonic irrigation	4	44.44	14	41.18	18	41.86		
	Total	9	100	34	100	43	100		
How many sessions do you complete for root canal treatment?	Single session	17	80.95	71	48.63	88	52.69	6.452	0.011
	Multiple session	4	19.05	75	51.37	79	47.31		
	Total	21	100	146	100	167	100		
If you perform multiple-session root canal treatment, which intra-canal medicament do you use between sessions?	Two-component antibiotic paste	0	0	1	1.35	1	1.28	*	0.99
	Phenol	0	0	1	1.35	1	1.28		
	CaOH	4	100	72	97.3	76	97.44		
	Total	4	100	74	100	78	100		
Which filling technique do you use?	Single cone technique	7	33.33	71	48.63	78	46.71	*	0.135
	Lateral condensation	13	61.9	74	50.68	87	52.1		
	Hot filling technique	1	4.76	1	0.68	2	1.2		
	Total	21	100	146	100	167	100		
Which restoration do you prefer after endodontic treatment?	Amalgam filling	0	0	14	9.59	14	8.38	*	0.308
	Composite filling	18	85.71	120	82.19	138	82.63		
	Crown	3	14.29	12	8.22	15	8.98		
	Total	21	100	146	100	167	100		
Which canal filling material do you use?	Bioceramic-based canal filling	4	19.05	15	10.27	19	11.38	*	0.144
	Zinc oxide eugenol-containing canal filling	0	0	12	8.22	12	7.19		
	Epoxy resin-based canal filling	12	57.14	60	41.1	72	43.11		
	Calcium hydroxide-containing canal filling	5	23.81	59	40.41	64	38.32		
	Total	21	100	146	100	167	100		

In a survey study, it was reported that 81.15% of dentists never use rubber dam, 0.64% always use it.[28] Similarly, another study conducted in Denmark found that 14% of dentists reported sometimes using rubber dam.[30] In a study by Ferreira et al.,[27] it was found that 99% of endodontists use rubber dam. In our study, 77.25% of participants reported not using rubber dam during root canal treatment. The low rate of rubber dam usage can be attributed to the difficulty and duration of application, as well as cost. We believe that the low rate of rubber dam usage in our country significantly reduces the prognosis of the endodontic treatments performed.

Wong et al.[31] reported that 67.8% of dentists do not use magnification, while 30.4% use loupes and 6.2% use a microscope. Another study showed that 86.5% of dentists do not use any magnification devices, 13.18% use loupes, and only 1 dentist uses a microscope.[28] In a further study, it was found that 67.38% of endodontists use magnification, with the magnification tools being 23.66% loupes, 35.48% microscopes, and 8.24% using a combination of both.[27] In our study, 91.02% of participants reported that they do not utilize magnification during root canal treatment. While 76.19% of endodontists and 93.15% of general dental practitioners do not use magnification during treatment, 0.68% of general dental practitioners reported that they sometimes use loupes or phone cameras. We believe that the use of magnifying devices should be increased due to the very small area used in root canal treatment and the anatomical differences of the teeth.

In our study, 53.89% of participants reported having attended any seminar/course related to endodontics after graduation. One study showed that the usage rates of loupes significantly increased with the number of hours of endodontic training received. The lowest rate of loupe usage was found among dentists who had not received any training in endodontics. It was observed that the rate of loupe usage increased with the number of endodontic training hours. Among those who reported never using rubber dam, 87.25% belonged to the group that had not received any endodontic training.[28] In a survey conducted by Madarati on dentists' use of rubber dam, it was reported that the usage rate was higher among those who received training (71.4%) compared to those who had not received any training (35.5%), indicating that endodontic training is associated with rubber dam usage.[32] We believe that the reason why there is not much difference between the endodontic treatment procedures of endodontists and general dentists is due to the courses taken.

Pratten stated that the use of EALs for determining working length is more reliable than radiography.[33] Hoer et al.[34] suggested that working length determination should be done using a combination of radiography and EALs. In a study conducted by Ünal et al.[26] in our country, it was shown that 12.8% of dentists use EALs. In a study by Iqbal et al.[35] in Saudi Arabia, 13.5% of dentists reported using this method, while Palmer et al.[36] found that 34.5% of dentists in their study in the UK preferred the combination of radiography and EALs. In our study, 62.28% of participants reported using the combination of radiography and EALs to determine working length. Additionally, there is no statistically significant relationship between titles and the techniques used to determine working length.

In a survey conducted by Meel et al.,[37] the usage rate of NiTi rotary file systems among general dental practitioners was reported to be 75%, while Guelzow et al.[38] found this rate to be 77%. In our study, 88.02% of participants reported using NiTi rotary files in routine root canal treatments. There is no statistically significant relationship between titles and the files used in routine root canal treatments.

Eleazer et al.[39] and Savani et al.[40] reported that 93% of dentists use sodium hypochlorite as an irrigation agent. Another study found that 91.05% of dentists use sodium hypochlorite solution as the primary irrigation agent.[28] In our study, 95.81% of participants use NaOCl/diluted NaOCl as their irrigation solution. However, there is no statistically significant relationship between titles and the irrigation solutions used. We believe that the reason why NaOCl is the most commonly used irrigation solution among endodontists and general dentists is that NaOCl still maintains its validity as the gold standard.

In a study by Savani et al.,[37] it was reported that 81% of dentists do not use any instruments or devices for irrigation activation, and the frequency of usage increases with training in endodontic courses/seminars. Another study found that 87.86% of dentists do not use any instruments for irrigation activation during the procedure.[26] In our study, 74.25% of participants reported not using any activation technique during irrigation. Among those who do use an activation technique, 41.86% reported using PUI. There is no statistically significant relationship between titles and the use of activation techniques during irrigation. In a study conducted by Ekici et al.,[41] it was observed that none of the activation methods used completely removed the debris. We believe that debris that cannot be completely removed even with the activation methods used will create a serious failure rate in root canal treatment without activation.

Studies have shown that endodontic treatments are mostly completed in multiple sessions.[28,30,31] Another study indicated that endodontists predominantly finish the treatment in a single session.[27] In our study, 52.69% of participants reported completing root canal treatment in a single session, while 47.31% completed it in multiple sessions. Among those who completed the treatment in multiple sessions, 97.44% used CaOH as an intracanal medicament. There is a statistically significant relationship between titles and the number of sessions required to complete root canal treatment.

In a study by Gupta et al.,[35] 61% of practitioners preferred the cold lateral compaction technique, while Iqbal et al.[42] reported that 63.5% of practitioners favored the same method. In our study, 52.1% of participants stated that they use the lateral compaction filling technique. However, there was no statistically significant relationship between titles and the filling techniques used.

In a study by Kaptan et al.,[43] epoxy resin-based sealers were reported as the most preferred sealer, and composite restoration was identified as the most commonly used final restoration material after root canal treatment. In our study, 43.11% of participants reported using epoxy resin-based sealers, while 82.63% preferred composite filling restorations after endodontic treatment. However, there was no statistically significant relationship between titles and the type of sealer used, nor between titles and the preferred restorations after endodontic treatment.

CONCLUSION

As a result of this study, it was seen that general dentists have sufficient knowledge about current root canal protocols and materials. It was also seen that endodontists have relatively more knowledge on this subject than general dentists. It is a very positive result that dentists are trying to improve their perspectives on root canal treatment with training and course requests.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of the Dicle University Faculty of Dentistry Ethics Committee (Date: 29.01.2020, Decision No: 2020-2).

Informed Consent

All participants signed a free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

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

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Review

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Utilization of artificial intelligence in pediatric dentistry: a comprehensive literature review

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ABSTRACT

Artificial intelligence (AI) refers to the creation of computer systems capable of performing tasks that typically necessitate human intelligence. Several dental specializations, such as pediatric dentistry, increasingly utilize artificial intelligence and its components, including machine learning and deep learning. The advancement of AI in healthcare is associated with the development of AI applications designed to assist medical practitioners in diagnosing patients and determining optimal treatment strategies. Artificial Intelligence refers to the ability of machines to acquire knowledge and utilize that information to perform various cognitive functions, such as language processing, learning, reasoning, and decision-making-essentially emulating human behavior. This article provides an overview of the various applications of AI that are advantageous to pediatric dentistry.

Keywords: Artificial intelligence, machine learning, deep learning, pediatric dentistry

INTRODUCTION

Early detection, management, and prevention of these issues are crucial for optimal dental health in children. In recent years, artificial intelligence (AI) has exhibited its utility in the dental and medical sectors.[1] The process of instructing a machine to emulate human cognition is referred to as artificial intelligence, or AI.[1,2] At a Dartmouth meeting in 1956, John McCarthy coined the term "artificial intelligence" for the first time.[1,3,4] AI solutions are more vital across various dental disciplines today. The creation of AI programs designed to aid doctors in patient diagnosis, therapy selection, and outcome prediction is associated with the utilization of AI in healthcare.[2]

The domain of artificial intelligence referred to as machine learning (ML) employs algorithms to predict outcomes based on a dataset.[2] By employing data to develop algorithms, machines can address predictive challenges independently of human intervention. A set of algorithms known as neural networks (NNs) utilizes artificial neurons to process signals. Artificial neurons that mimic human neural networks are employed in neural networks, which utilize mathematical models to replicate the human brain. Neural networks provide the capability to emulate human cognitive functions, including problem-solving, reasoning, learning, and decision-making, among others. Neural networks comprise three fundamental layers: the input layer, which acquires user input; the hidden layer, which processes the data; and the output layer, where the system renders decisions.[5] Artificial neural networks (ANN), convolutional neural networks (CNN), and recurrent neural networks (RNN) are the three predominant forms of neural networks. Neural networks encompass deep learning, enabling computers to autonomously interpret data. The concealed layer of deep learning neural networks may contain anything from several thousand to several million neurons.[2,3,6] Neural networks assist in training computers to respond suitably to situations, rather than prescribing specific actions.[7] Advanced AI technologies are better suitable for application with 3D CNN in dentistry for clinical purposes, such as cone beam computed tomography (CBCT). CBCT, necessitating substantial radiation exposure, can be supplanted in endodontics by three CNNs capable of identifying anatomical structures and dental caries. They are also crucial in the domain of oral pathology.[1] Artificial narrow intelligence (ANI), artificial general intelligence (AGI), and artificial superintelligence (ASI) constitute the three primary classifications of artificial intelligence. ANI, commonly known as weak AI, possesses restricted capabilities suitable for highly specific jobs. These systems perform solely the specific function for which they were designed. Referred to as "strong" or "deep AI," AGI possesses the capability to resolve problems in a manner akin to that of a human. In dentistry, neural networks can enhance diagnostic accuracy, speed, and efficiency.[4]

AI is a contemporary technical advancement that has rapidly gained prominence in the domain of science and technology.

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AI significantly depends on imaging, which serves as a fundamental element in dentistry to a considerable degree. Artificial intelligence is exceptionally advantageous in the constant assessment and monitoring of a patient's health, comprehending the long-term impacts of pharmaceuticals, and identifying potential health-related risks in advance.[8,9] AI has the capacity to entirely eradicate the extensive hours dedicated by dental practitioners. Moreover, it is possible to enhance individuals' health at reduced expenses, deliver personalized, preventive, and predictive dental care, and unify healthcare for all. Primarily, AI possesses the capacity to enhance dental care standards, refine diagnostic accuracy and efficacy, generate superior treatment images, model outcomes, and forecast oral diseases and health conditions.[8-10] AI models have garnered attention for their role as supplementary tools, enhancing the precision and accuracy of diagnosis. AI technology has been extensively utilized in medical sciences, exhibiting exceptional efficacy in many patient care activities, including disease diagnosis and assessment of a patient's risk for disease development, among others.

A primary motivation for this study is the rapid increase in recent studies concerning neural networks in dentistry. In pediatric dentistry, artificial intelligence possesses numerous promising applications that could transform pediatric practice in the forthcoming years. The objective of this research was to investigate the several applications of AI in pediatric dentistry.

CLASSIFICATION OF AI

AI can be implemented through various methods, with different types designed to perform distinct tasks. Researchers have proposed multiple classification approaches for AI.

All non-human intelligence falls under the category of AI, which is further divided into weak AI and strong AI. Strong AI possesses intelligence and capabilities equivalent to those of humans, aiming to develop a multitasking algorithm for decision-making.

Weak AI encompasses expert systems and machine learning as separate categories. Currently, deep learning, a subset of machine learning, is one of the most actively researched fields. Convolutional neural networks (CNNs) are a type of deep learning model widely used for image generation and recognition. Among deep learning algorithms, generative adversarial networks represent an unsupervised learning approach designed to autonomously identify patterns in input data and generate new data with similar characteristics.[3,11-14]

The evaluation of existing AI applications in pediatric dentistry remains inadequate. Therefore, this review aims to provide an update on the effectiveness of AI as a diagnostic tool in pediatric dentistry.

The benefits of AI are substantial. ML and DL, as subfields of AI, have proven to be valuable tools in enhancing clinical decision-making. They improve monitoring, efficiency, accuracy, and precision while also saving time. AI helps reduce the duration of investigations and contributes to better public health outcomes while lowering costs. Additionally, it enables personalized, anticipatory, and preventive dental care.

However, AI also has its limitations. The availability of datasets remains a challenge, with only a limited number of AI-based models capable of identifying images beyond the scope of two-dimensional panoramic radiography. Furthermore, datasets from single institutions are not widely accessible, limiting the generalizability of AI applications.[3]

AI APPLICATIONS IN PEDIATRIC DENTISTRY

AI plays a significant role in diagnostics, decision-making, treatment planning, and outcome prediction. Its impact on diagnosis has been particularly notable, leading to substantial advancements in accuracy and efficiency.[15]

Dental Caries Detection

AI systems can accurately outline teeth, detect caries, and generate valuable predictions. They assist in diagnosing common pediatric dental conditions, such as tooth decay, by analyzing X-Rays and intraoral images while also playing a role in patient education.[15] Talpur et al.[16] conducted a study using DL techniques to diagnose dental caries through image analysis. Additionally, algorithms can be applied to delineate anatomical and pathological structures. An artificial neural network was specifically employed to detect the presence of caries.[4]

ML-based models utilize simple questionnaires and assessments to predict the presence of early childhood caries (ECC) in preschool-aged children. A novel caries risk prediction model incorporating genetic and environmental components was established. Key factors from the parent questionnaire are identified using a machine learning technique known as random forest throughout the COVID-19 period to predict the presence of active caries.[1] Data has been trained up to October 2023. Karhade et al.[17] employed a questionnaire and machine learning to diagnose dental caries. The results indicated that ECC can be accurately detected and classified.

Evaluation of Children's Oral Health and Management

AI identifies potential risk factors affecting children's dental health and revolutionizes the processes of data collection, organization, and utilization, ultimately enhancing the quality of care provided to pediatric and adolescent patients. Its advanced data management capabilities offer pediatric dentists a structured and standardized framework for organizing extensive medical records. This streamlined approach enables quick access to critical information regarding a child's dental history, facilitating the development of personalized, patient-centered treatment plans.[15] You et al. developed a comprehensive AI-powered toolbox for assessing pediatric dental health.[3,15] ML models and algorithms enhance dental practitioners' understanding and cognitive abilities. They analyze patient data, medical records, and other relevant information to generate predictions and treatment recommendations.[15] AI is utilized in orthodontics for treatment planning, identifying cephalometric landmarks, and predicting treatment outcomes.[11] AI has been applied to the identification of dental sealants using CNNs. An AI-driven approach demonstrated higher diagnostic accuracy compared to traditional CNN-based classification methods, enhancing the reliability of sealant detection and evaluation.[1]

Age Estimation in Children

Zaborowicz et al.[18] utilized three deep neural network models to determine the chronological age of children and adolescents aged 4 to 15. Their research indicated that neural modeling

systems could precisely ascertain metric age using proprietary dental and skeletal characteristics.

Detection of Teeth and Dental Anomalies

A single deep learning model is utilized for the diagnosis of mesiodens. This deep learning approach facilitates the identification and early detection of abnormalities in both permanent and deciduous teeth, enhancing diagnostic accuracy and clinical decision-making.[1,19] CNNs, one of the most widely used DL architectures, are commonly applied in object recognition. In pediatric dentistry, deciduous teeth are increasingly analyzed using DL techniques such as CNNs. The R-CNN inception model has demonstrated high accuracy in tooth identification. Additionally, AI has accurately detected the ectopic eruption of the first permanent molar.[1] Bulatova et al.[20] assert that the AI-based model demonstrated superior efficiency in recognizing cephalometric landmarks compared to manual tracing.

Endodontics

AI supports the assessment of root canal system anatomy, working length measurements, periapical disease and root fracture diagnosis, and retreatment outcome prediction.[4] Zheng et al.[21] reported that a multimodal CNN demonstrated high accuracy when comparing three different CNN models for diagnosing pulpitis and deep caries in intraoral periapical radiographs.

General Dentistry

AI enhances precision in shade matching, improving restorative dentistry outcomes.[4] CNN algorithms have proven effective in the automated detection of cancer and periodontal disease.[11] Research has shown that CNNs successfully identify dental plaque on primary teeth using intraoral photographs, providing clinically significant findings.[22] Additionally, AI-supervised nanorobotic techniques offer the potential for painless procedures by enabling precise local anesthetic delivery.[3]

The primary challenges in integrating AI into dentistry involve the application of AI algorithms in healthcare, particularly concerning the exchange and storage of clinical data. While AI cannot fully replace a dentist's diagnostic process, it can support general and pediatric dentists by enabling faster diagnoses with greater accuracy.[1]

CONCLUSION

Artificial intelligence has emerged as a transformative force in pediatric dentistry, enhancing diagnostic accuracy, treatment planning, and patient management. AI-driven technologies, including machine learning and deep learning models, have demonstrated significant potential in early detection, risk assessment, and personalized dental care for pediatric patients. From detecting dental caries and assessing occlusion to automating image analysis and predicting treatment outcomes, AI applications are redefining clinical workflows and improving efficiency. Despite these advancements, several challenges remain, including the need for high-quality, diverse datasets, regulatory approvals, and ethical considerations related to patient privacy and data security. Further research is essential to refine AI-based models, validate their clinical effectiveness, and integrate them seamlessly into routine pediatric dental practice.

By continuously exploring AI's capabilities, clinicians can leverage this technology to improve treatment outcomes, optimize clinical decision-making, and ultimately enhance pediatric oral healthcare. Collaborative efforts between researchers, clinicians, and technology developers will be pivotal in overcoming existing limitations and ensuring AI's safe, ethical, and effective implementation in pediatric dentistry.

ETHICAL DECLARATIONS

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Journal of Dental Sciences and Education

Case Report

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Management of surgical treatment with autogenous graft for papilla reconstruction in cases of peri-implant papilla loss: 3-month follow-up

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ABSTRACT

The interdental papilla is a crucial structure of the gingiva, and its height may decrease or be completely lost due to various factors. This loss often results in an open embrasure space commonly referred to as a "black triangle." Black triangles are aesthetically displeasing and frequently a cause of patient complaints. Understanding the available treatment methods for addressing this condition is vital for clinicians. A 43-year-old female patient presented to our clinic with complaints of black triangle spaces caused by papilla loss in the region of implant #13. Evaluations revealed a reduction in the papilla height in the mesial and distal areas of the peri-implant region, with no evidence of peri-implant mucositis or peri-implantitis. After obtaining informed consent, an autogenous soft tissue graft was harvested from the patient's palatal region during the same session and placed at the recipient site. The healing process was monitored postoperatively.

Keywords: Interdental papilla loss, papilla reconstruction, autogenous graft, de-epithelialized FGG

INTRODUCTION

The interdental papilla is the gingival tissue that fills the embrasure space located between the contact points of adjacent teeth. Its structural integrity is maintained through support derived from the boundaries of the underlying alveolar bone and the surrounding teeth.[1] Composed of masticatory mucosa, this structure has a dense connective tissue composition and is covered with oral epithelium (non-keratinized stratified squamous epithelium).[2] The shape of the interdental papilla is determined by the contact points between adjacent teeth, the width of the interproximal tooth surfaces, and the contour of the cementoenamel junction (CEJ). While the interdental papilla exhibits a pyramidal form in anterior teeth, in posterior regions, it appears as two papillae connected by a concave saddle-shaped structure called the "col" region. The col structure may exhibit parakeratinized or non-keratinized tissue characteristics.[3] Papillary height gradually decreases as one moves from anterior to posterior regions, with the interproximal contact area reaching its highest level between the central incisors.

Conversely, the width of the col region increases as it progresses along the arch. The interdental papilla plays a significant role in shaping the scalloped contour of the gingival margin. Initially, the interdental papilla was thought to serve solely the function of "removing food debris." However, it was later suggested that the interdental papilla could also function as a barrier and defense mechanism by protecting the underlying periodontal tissues.[3] Upon examining samples taken from dental students, "round cell infiltration" was identified within the interdental papillae. This inflammatory cell infiltrate is believed to represent a defensive response to continuous bacterial invasion, resulting from the accumulation of dental plaque.

The presence of the interdental papilla also plays a crucial role in aesthetics. A clinical study conducted by Tarnow et al.[4] investigated the relationship between the distance from the most coronal point of the interdental bone crest to the apical edge of the contact point between teeth and the presence or absence of the interdental papilla.

This study included a large sample of 288 interdental sites from 30 randomly selected patients. The results revealed that as the distance (measured in millimeters) from the contact point to the bone crest increased, the likelihood of the presence of the interdental papilla decreased. When the distance was 3-4 mm, a complete interdental papilla was present in all sites (100%). At 5 mm, the papilla was observed in 98% of the sites. However, when the distance reached 6 mm or more, partial or complete absence of the interdental papilla was noted. With each millimeter increase, the probability of papilla presence significantly declined. The study concluded that the height of the interdental papilla is determined by the vertical height of the underlying bone.

Joshi et al.[5] conducted a cross-sectional study involving 150 interdental sites across 30 patients to evaluate the factors

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influencing interdental papilla fill. According to the study's findings, when the crown width-to-length ratio exceeded 0.88 and the distance between the bone crest and the contact point was 5 mm or less, complete interdental papilla fill was significantly associated with the tooth form or shape. Additionally, a higher gingival angle and increased gingival thickness demonstrated a strong correlation with the presence of healthy and well-formed papillae.

Various Causes of Loss of Interdental Papillae

Periodontitis and bone loss: The interdental papilla can be lost due to periodontitis, which results in interproximal bone loss. Treatment of periodontitis can lead to the formation of black triangles. This condition becomes more apparent in both non-surgical and surgical approaches-especially in pocket elimination or resective surgical procedures. Additionally, necrotizing periodontal diseases may also contribute to the formation of black triangles.

Iatrogenic factors: Tissue damage resulting from over-contoured restorations or improper crown preparations can cause the loss of the interdental papilla. Other factors, such as traumatic brushing habits, overuse of interdental aids, behaviors like chewing on pens, or gingival trauma from piercings, can also lead to papilla loss.

Tooth-related factors: Factors such as loss of contact points, misalignment of teeth, abnormal tooth shapes, triangular crowns, diastemas, divergent roots, and excessive eruption of teeth may also result in interdental papilla loss.

Orthodontic treatment: Orthodontic treatment is another factor that can lead to interdental papilla loss. Black triangles are reported to occur in 38% of adult patients after orthodontic treatment.[6]

Prevalence of black triangles post-orthodontic treatment: A systematic review conducted by Rashid et al.[7] examined the prevalence of black triangles following orthodontic treatment. This review, which included five studies, found that the prevalence of black triangles ranged from 38% to 58% after orthodontic treatment. The authors identified risk factors associated with black triangle formation as age, tooth-related features, treatment duration, and patient-related factors.

The classification of interdental papilla is essential for assessing the current condition and determining the prognosis. The height of the interdental papilla may vary in degrees of loss. Classification systems developed for this purpose provide a valuable guide for clinicians, enabling standardized care practices. These classifications serve as a foundation for diagnosis, prognosis determination, and treatment planning. Furthermore, they are crucial for ensuring data homogeneity and facilitating data integration for research purposes, such as systematic reviews and meta-analyses.

In 1998, Nordland and Tarnow[4] proposed a classification system based on three reference points to assess losses in interdental papilla height: the contact point, the buccal-apical extension of the cementoenamel junction (CEJ), and the interproximal CEJ. This classification is defined as follows:

Normal: The interdental papilla completely fills the embrasure space up to the apical portion of the interdental contact point/area.

Class I: The tip of the interdental papilla lies between the interdental contact point and the most coronal extension of the CEJ.

Class II: The tip of the interdental papilla is at or apical to the interdental CEJ but more coronal than the buccal CEJ's apical extension.

Class III: The tip of the interdental papilla is at or apical to the buccal CEJ's apical extension.

In 2004, Cardaropoli introduced a new classification system for evaluating interdental papilla height called the Papilla Presence Index (PPI). This system grades the presence of the interdental papilla using four distinct scores:

Score 1: The papilla is completely present.

Score 2: The papilla is partially lost, but the interdental CEJ is not visible.

Score 3: The papilla is completely absent, and the interdental CEJ is visible.

Score 4: The papilla is completely absent; both the buccal and interdental CEJ are visible.

The loss of the interdental papilla can result in the formation of black triangles, which are aesthetically unpleasing and may lead to food impaction and phonetic difficulties. These issues negatively impact the patient's oral health-related quality of life and self-esteem.[8] Due to its aesthetic impact, dentists frequently face requests to manage or reconstruct lost interdental papillae. Treatment options for papilla reconstruction can be surgical, non-surgical, or ortho-restorative in nature.[9] The flap was then closed with simple interrupted sutures along the incision line using 4.0 silk sutures. Bleeding was controlled at both donor and recipient sites, and moist gauze was applied to the area with pressure to aid hemostasis.

CASE

During anamnesis, a 43-year-old female patient with no systemic disease or medication history was found to have previously sought treatment for tooth #13, which had undergone root canal therapy. At the clinic she visited a year earlier, extraction was recommended, and implant placement was planned.

Following the extraction, hard and soft tissue healing was observed, and approximately three months later, dental implant surgery was performed in the region. During the osseointegration period, when a flap was raised to place the healing abutment, mobility of the implant was noted. The implant was removed, and the area was left to heal again. Two months later, a new dental implant was placed, and the healing process was monitored. At the end of the osseointegration period, successful healing was confirmed, and the prosthetic phase was initiated. However, during the preparation and follow-up of the prosthetic restoration, black triangular spaces due to papilla loss became evident. For aesthetic evaluation, the patient was referred to the periodontology clinic (**Figure 1**). During clinical examination, no signs of inflammation, such as bleeding on probing, redness, edema, or pus discharge, were observed in the peri-implant mucosa. Adequate keratinized tissue was also noted, and the probing depth was measured at 4 mm.

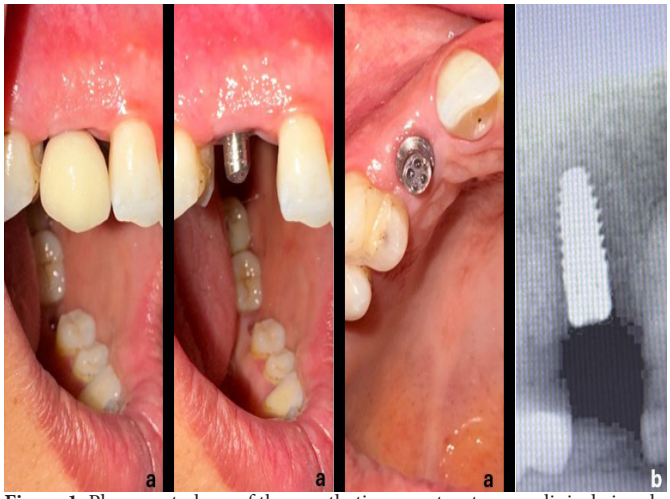

Figure 1. Placement phase of the prosthetic superstructure: a. clinical view, b. radiographic view

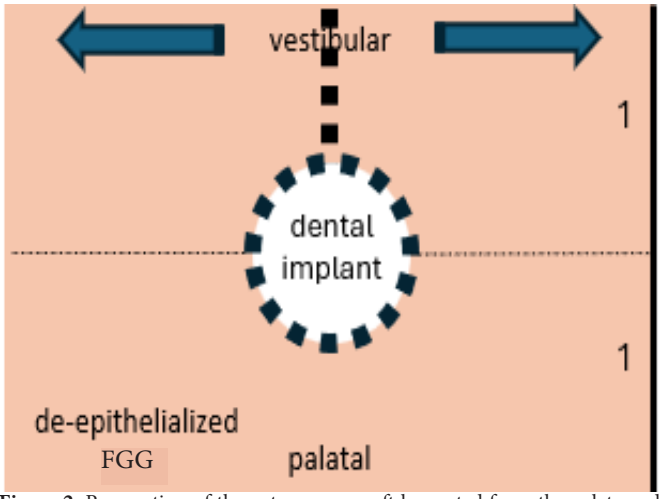

Figure 2. Preparation of the autogenous graft harvested from the palate and de-epithelialized before placement in the recipient site. A space was left on the graft for the abutment area, and the graft was incised into two equal parts on its vestibular half to provide volume in the mesial and distal papilla regions

The absence of a prosthetic restoration during the procedure guided the decision to prioritize graft stabilization. To reconstruct the papilla, it was decided to use a free gingival graft harvested from the palatal region on the same side, which would be de-epithelialized before placement.

Following routine surgical preparations, a soft tissue graft was harvested from the upper right quadrant. Under infiltrative anesthesia, a free gingival graft approximately 2 mm thick and wide enough to match the mesiodistal distance between teeth #12 and #14 was obtained from the palatal gingival contours, 2-3 mm away from the palatal surfaces of teeth #14 and #15. Once the graft was fully detached, the oral-cavity-facing portion was de-epithelialized. Hemostasis at the donor site was achieved, and a suspension suture was placed using 4.0 silk sutures (İpek Plastic Inc., İstanbul, Turkiye), secured to the adjacent teeth. At the recipient site, an incision was made from the distal-palatal point of tooth #12 to the mesial-palatal point of tooth #14 using a #15 blade without contacting the bone. The incision line continued intrasulcularly along the interdental surfaces of the adjacent teeth and extended into the vestibular area. A partial-thickness flap was raised, preparing the recipient site for graft placement. The graft was positioned in a way that did not interfere with the prosthetic restoration and extended into both papillary regions to fill the existing void. It was divided into two equal parts along the vestibular incision to address the papillae on both sides. The graft was stabilized to the underlying tissues with Vicryl sutures (Setpa Medical Equipment LTD. STI., İzmir, Turkiye), ensuring immobility (**Figure 2**). The flap was then closed primarily using simple interrupted sutures along the incision line with 4.0 silk sutures (İpek Plastic Inc., İstanbul, Turkiye). Bleeding was controlled at both the donor and recipient sites, and moist gauze was applied with pressure to maintain hemostasis.

Following the procedure, the patient was prescribed Biprofenid 100 mg (Sanofi Pharmaceutical Industry and Trade Inc., Kırklareli, Turkiye) to be taken twice daily and Kloroben 1.5 mg/ml+1.2 mg/ml mouthwash (Drogsan Pharmaceuticals Industry and Trade Inc., Ankara, Turkiye) to be used twice daily. A follow-up appointment was scheduled for the 10th postoperative day. The 1-month follow-up image is shown in **Figure 2**. During the postoperative healing period, the recovery was uneventful. Sutures were removed on the 14th day. At the 1-month follow-up, the patient reported no complaints, and the surgical site was observed to have healed with appropriate closure. At the 3-month follow-up, a loss of mesial and distal papillae was observed, as shown in **Figure 3**. Radiographic evaluation revealed over 50% bone loss in the region. Clinical examination measured a probing depth of 9 mm with bleeding on probing. The patient was informed, and peri-implantitis treatment was initiated. No mobility, pus discharge, or pain complaints were reported (**Figure 4**).

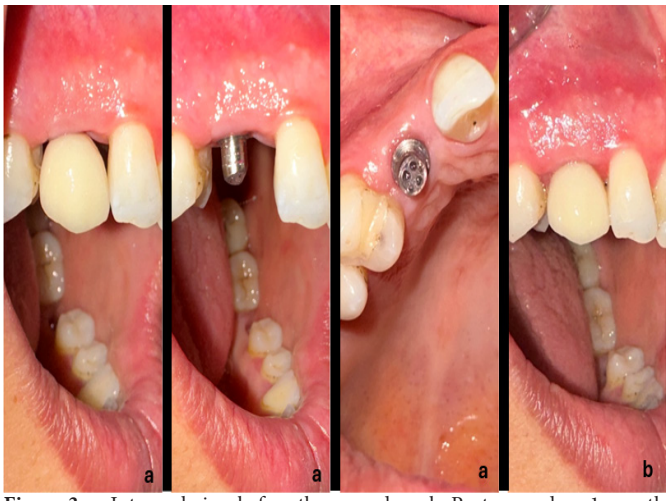

Figure 3. a. Intraoral view before the procedure, b. Post-procedure 1-month follow-up showing filling in the mesial and distal papilla regions

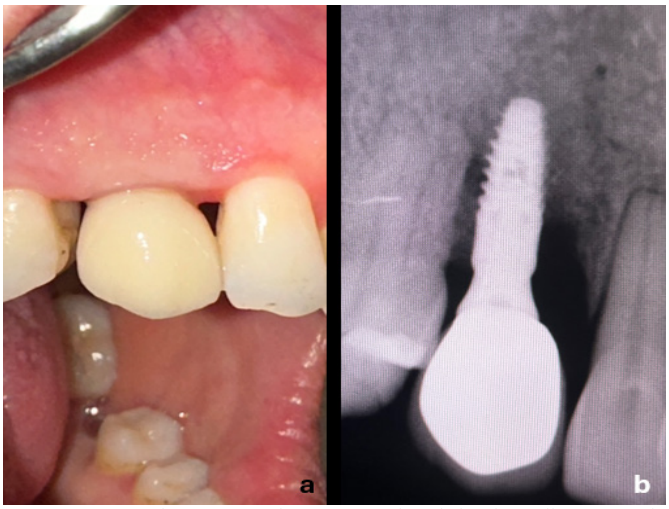

Figure 4. 3-month post-procedure: a. mesial and distal papilla regions, b. radiographic view

DISCUSSION

The height of the gingival papilla is influenced by various factors, including anatomical structures, the degree of inflammation, the distance from the interproximal bone crest to the contact point, and previous surgical or non-surgical treatment methods.[10] Among these factors, the most critical is the distance between the bone crest and the contact point. Tarnow and colleagues found that 98% of gingival papillae between natural teeth remained intact when the distance from the bone crest to the contact point was ≤5 mm. However, when this distance increased to 6 mm and ≥7 mm, the intact papilla rates dropped to 56% and 27%, respectively.[10,4] The findings from the follow-up in our study align with Tarnow et al.'s[4] results, demonstrating that an increase in probing depth reduces the amount of intact papillae. The lack of gingival papilla is a complex issue, both aesthetically and functionally.[11] According to the Jemt Papilla Index, gingival papilla defects are categorized into five levels based on their degree of fill: 0: No papilla is present. 1: Less than half of the papilla height is present. 2: Half or more of the papilla height is present. 3: The papilla fills the entire proximal space. 4: The papillae are hyperplastic. Loss of gingival papilla height leads to the formation of black triangles, which disrupt the aesthetics of the anterior teeth. Additionally, gingival papilla defects can cause food impaction and plaque accumulation, further compromising periodontal health. Numerous studies have explored the reconstruction of the gingival papilla. However, creating papillae in the esthetic zone remains challenging due to its complexity and the interplay of multiple factors.[12]

For papilla reconstruction, treatment options include the use of hyaluronic acid, platelet-rich fibrin (PRF), soft tissue grafts, and orthodontic treatment, encompassing both surgical and non-surgical approaches.[13] Surgical methods are typically invasive and may yield unpredictable results.[14,15] Although some non-surgical studies involving hyaluronic acid report favorable outcomes due to its biocompatibility and high patient satisfaction, repeated injections and the associated cost must be considered.[16] Additionally, in certain cases, a minimally invasive autologous approach has been applied using the interdental papilla reconstruction technique (i-PRT), enhanced with injectable platelet-rich fibrin (i-PRF). This method leverages autologous biological materials to support papilla reconstruction while minimizing invasiveness. Beagle described a technique involving a horizontal incision on the palatal side combined with two vertical incisions to separate a split-thickness flap. The gingival flap was then sutured and secured to the buccal side. Han and Takei,[17] pioneered the restoration of missing gingival papillae using a combination of crescent-shaped incisions and connective tissue grafts (CTG), achieving favorable surgical outcomes.[18]

CONCLUSION

The reconstruction of the gingival papilla is considered a challenging technique within the field of periodontal mucogingival surgery. This case report describes the use of autogenous de-epithelialized free gingival grafts for papilla reconstruction in a patient dissatisfied with the aesthetic outcome due to papilla loss, along with a 3-month follow-up. A thorough evaluation of clinical follow-ups and the patient's procedural history plays a crucial role in determining the prognosis of surgical interventions.

ETHICAL DECLARATIONS

Informed Consent

The patient signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

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

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Journal of Dental Sciences and Education

Case Report

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Aesthetic rehabilitation of a case of polydiastema in the upper anterior region with direct composite restoration using the injection molding technique: case report

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ABSTRACT

Diastema is the gap between the teeth or mesiodistal gaps caused by the size difference of the teeth. More than one diastema in the jaw is called "polydiastema." Polydiastema can occur for various reasons. These reasons include harmful habits and genetic or systemic disorders. In this case report, restoration of an anterior polydiastema case with direct flowable composite resin is described. A 29-year-old female patient was admitted to our clinic with a gap between her maxillary teeth. Treatment options were evaluated with the patient, and it was decided to close the diastema with direct composite resin restoration using injection molding technique. After the restoration was completed, finishing and polishing procedures were performed. In the control examination, it was determined that the restorations met the patient's aesthetic expectations.

Keywords: Anterior aesthetics, polydiastema, flowable composite resin, injektion molding

INTRODUCTION

Today, with the increasing awareness of people, the aesthetic factor has started to gain importance. In the past, the patients' wish was to avoid pain, whereas now aesthetics has also become more important. More often, color, shape, and position disorders in anterior teeth cause aesthetic and psychosocial problems in patients.[1]

Gaps between the anterior teeth are defined as diastema. The gap or diastema in the anterior maxillary region is a common aesthetic problem in patients.[2] In the etiology of diastema; labial frenulum, microdontia, mesiodens, wedge-shaped lateral incisors, cysts in the midline region, habits such as finger sucking, tongue thrusting and/or lip sucking, dental defects, genetics, maxillary incisor proclination, dental-skeletal incompatibilities and defective union of the interdental septum should be considered as factors that may cause diastema.[3,4]

The duration of diastema treatment has become an important criterion. In the past, crown restorations with loss of tooth substance were applied to correct deformities in the anterior teeth.[5] Nowadays, laminates, orthodontic treatments, or direct adhesive restoration applications have become alternative options.[6]

Recent developments in adhesive systems allow restorations to be made without touching the tooth structure or with minimal material removal. In addition, thanks to advancing technology, the size of filler particles in composite resins has been reduced and the polishability and optical properties of composites have been improved. Composite resins used today offer various color and opacity options to physicians.[7]

CASE

In this case report, a 30-year-old female patient with diastema of the maxillary anterior teeth was admitted to the Dicle University Faculty of Dentistry, Restorative Dentistry Clinic. On examination, the patient was periodontally healthy and had a normal vertical bite (**Figure 1**).

Figure 1. Intraoral view of the polydiastema before restorative treatment

The patient was examined and informed about appropriate treatment options. The patient agreed to treatment with

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composite resin. First, an impression was taken from the patient with silicone. Then, our impression was waxed up by the technician over the plaster model. The wax-up was presented to the patient's liking with a mock-up application in the patient's mouth with acrylic that hardens in the mouth. After the patient's approval, color selection was made. The tooth surfaces were then individually roughened with 37% orthophosphoric acid gel (Ruby Etch, İstanbul, Turkiye) for 30 seconds. Two-stage self-etch adhesive G-BOND (GC Europe, Tokyo, Japan) was applied to the abraded surfaces. After waiting for 5-10 seconds, it was dried with compressed air for 5 seconds and then polymerized with a halogen light device for 20 seconds. The teeth next to the tooth were protected with Teflon tape, the apparatus we obtained with a transparent impression was placed in the patient's mouth, and a high-filling flowable composite resin [G-aenial Universal Flo (GC Corporation, Tokyo, Japan)] was placed through the hole we drilled incisally. It was then polymerized for 20 seconds. After repeating these procedures for the anterior 6 teeth, necessary corrections were made. Finishing and polishing procedures were performed using fine-grit diamond burs, polishing discs (RubyPlaton, İstanbul, Turkiye), and elastics (Clearfil Twist Dia, Kuraray, Japan). The patient was called for a check-up after 6 months. No aesthetic problems were found (**Figure 2-4**).

Figure 2. Direct composite restoration using the injection molding technique

Figure 3. Intraoral view after finishing and polishing procedures

Figure 4. Intraoral view after restorative treatment

DISCUSSION

The presence of discoloration and diastema in the anterior teeth, which directly affect smile aesthetics, becomes more important, especially in young patients. Diastemas can be treated with surgical, prosthetic, orthodontic, or restorative applications or their combination depending on the case and factor.[8] Advancements in adhesive techniques and materials have made it possible to use composite resin materials safely in anterior aesthetic cases, providing physicians with much easier and faster solutions. In the treatment of diastema cases, a treatment protocol xis determined by considering many factors, such as the age of the patient, the size of the diastema, time, and cost. Advantages and disadvantages are evaluated, and indirect or direct technique is decided. Composite restorations made by blending into the tooth surface are the most preferred treatment method because they can be applied in a single session, the application time is short, and the cost is low. Another advantage of this treatment method is the option of repair in case of any fracture in the restoration.[9]

Today, diastema closure has become a frequently performed procedure in the clinic as a result of increased aesthetic expectations. Direct composite resin restorations in diastema treatments, besides being a non-invasive approach, have yielded functional and aesthetic satisfactory results for both the patient and the physician.[10]

According to studies, it has been reported that composite resin restorations cannot provide enamel-like reflection and transparency, especially in the anterior regions when compared with ceramic restorations.[11] Composite resins have disadvantages such as surface roughness, polymerization shrinkage, microleakage, fragility, and low wear resistance. Contamination of the resin with blood or saliva during restoration, inadequate polymerization, faulty finishing and polishing processes, or color changes due to smoking and dietary habits are important disadvantages for composite resin restorations.[12] In recent years, these criticisms have decreased with the production of ceramic-added composite resins with color scales of different opacities, such as enamel and dentin. Nowadays, direct composite resin restorations have come to the forefront among conservative restoration options based on the principle of maximum tooth tissue preservation. Direct composite resin restorations, which are

less costly and can be completed in a single session compared to those made with the indirect method, exhibit less marginal leakage since they do not require an intermediate bonding agent, and accordingly, the risk of discoloration and caries formation between the restoration and tooth tissue is reduced. Another advantage of composite resin restorations is that they can be easily repaired with a similar composite resin and binding agent if fracture occurs.[13]

CONCLUSION

The technique we used in this case shortens the time the physician spends at the bedside. Since we do not have a mock up available in other techniques, first measurements are made to ensure that the teeth are of the appropriate length and width, and then composite resin is added to them accordingly. However, in the injection molding method, since we take measurements from the mock up we have, it has already taken the shape of the teeth. It is not necessary to shape additional teeth. The injection molding technique provides the opportunity to utilize the manual skill of both the physician and the technician. It allows the physician to give the most suitable form to the tooth shape by spending less time. In addition to these, there are also application difficulties. This technique can be used on both anterior and posterior teeth, but it is not used much in the posterior as it is more difficult to use.

ETHICAL DECLARATIONS

Informed Consent

The patient signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

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

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Case Report

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Lingual frenulum surgery in the treatment of ankyloglossia: case series

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ABSTRACT

The aim of this case series is to evaluate the clinical outcomes of lingual frenectomy in two young adult female patients with ankyloglossia and to emphasise the impact of surgical intervention on speech ability, tongue mobility and overall oral function. Two women, aged 22 and 19 years, presented with speech difficulties, restricted tongue movement and high lingual frenulum attachment. Clinical examination revealed associated conditions such as midline diastema, infantile swallowing patterns and labial displacement of the mandibular anterior teeth. After informed consent, both patients underwent lingual frenectomy under local anaesthesia using a #15 scalpel and blunt dissection technique. Sutures were placed with a continuous suture technique, and postoperative care included antibiotics, analgesics, and chlorhexidine mouthwash. Patients were followed up for six months. Both patients experienced significant improvements in tongue mobility and articulation after the procedure. No complications such as excessive haemorrhage or nerve damage were observed. At the six-month follow-up, the healing process was uneventful. They were then referred to the orthodontic clinic for further treatment of midline diastema, labial displacement and swallowing dysfunction. Ankyloglossia can cause functional and psychological problems by affecting speech, swallowing and tooth alignment. Early diagnosis and timely surgical intervention, such as lingual frenectomy, can contribute to significant improvements in tongue mobility and speech function. Long-term follow-up and interdisciplinary treatment are essential to achieve optimal patient outcomes.

Keywords: Abnormal frenulum, ankyloglossia, lingual frenectomy

INTRODUCTION

Ankyloglossia, also known as tongue tie, is a congenital condition of the lingual frenulum that is characterized by the restriction of the tongue's functions.[1] The lingual frenulum is a small fibro-mucosal plica that runs along the midline of the underside of the tongue and connects it to the floor of the mouth's mucosa, playing an important role in stabilizing and limiting the movement of the tongue.[2] In some individuals, the frenulum's strands adhere to the tip of the tongue, restricting its physiological movements. People with tongue-tie are unable to protrude their tongue past the incisal edge of the mandibular anterior teeth or touch the roof of the mouth.[3] The most significant clinical symptoms of this condition is the limited movement of the tongue. Other associated symptoms include feeding difficulties, weak sucking in infants, orthodontic problems, periodontal issues related to tooth bracing, speech, swallowing, and breathing difficulties.[4,5] The prevalence of tongue-tie is reported to be between 2% and 4.8% in a study by Lalakea and Messner.[6] Tongue tie is more common in males than females and does not show a racial predisposition.

Treatment options for ankyloglossia include partial removal of the frenum, known as "frenotomy," repositioning of the frenum, referred to as "frenuloplasty," and complete removal of the frenum, known as "frenectomy".[7] However, there is insufficient evidence in the literature to support any particular technique for the surgical treatment of ankyloglossia.[8] Lingual frenectomy is typically performed using a scalpel, electrocautery, or soft tissue laser. Although the procedure may appear simple, the anatomical location of the lingual frenulum, which is rich in nerves and blood vessels, makes it prone to complications.[9] This case report presents two successful cases of lingual frenectomy in patients with ankyloglossia.

CASE 1

A 22-year-old female patient admitted to the Department of Periodontology at the Faculty of Dentistry, Dicle University, due to difficulty in pronouncing certain words and letters, and limited tongue movement. A thorough medical history check revealed no underlying systemic disease.

During the intraoral examination, it was observed that the patient had a high lingual frenulum attachment, which prevented her from placing her tongue behind of the mandibular incisors and from protruding her tongue outside

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the mouth. Clinical examination revealed that this condition led to midline diastema and an infantile swallowing pattern (**Figure 1**).

Figure 1. Intraoral view of the high lingual frenulum attachment, ankyloglossia and midline diastema

After a general examination, an informed consent form was obtained, and a lingual frenectomy indication was established. Before the procedure, bilateral lingual block and local infiltrative anesthesia were administered. The frenulum was fixed with a hemostat and excised by making 2 incisions on the upper and lower sides of the hemostat with a #15 scalpel, paying attention to the lingual nerve and its branches (**Figure 2**). Then, blunt dissection was performed and the wound edges were closed without tension. The incisions were then sutured using a 3-0 suture with continuous suturing technique (**Figure 3**). Since the tongue has a strong muscular structure and is a mobile tissue, silk suture with high mechanical resistance and knot security was preferred. Postoperatively, the patient was prescribed 0.2% chlorhexidine digluconate mouthwash, antibiotics (Amoxicillin+clavulanic acid 625 mg film tablet) and analgesics (Etodolac 400 mg tablet) twice a day for a week. The reason for prescribing antibiotics in our cases is to provide a better recovery by preventing surgical site infections, which can be a source of concern in oral surgery due to the high bacterial load in the mouth.

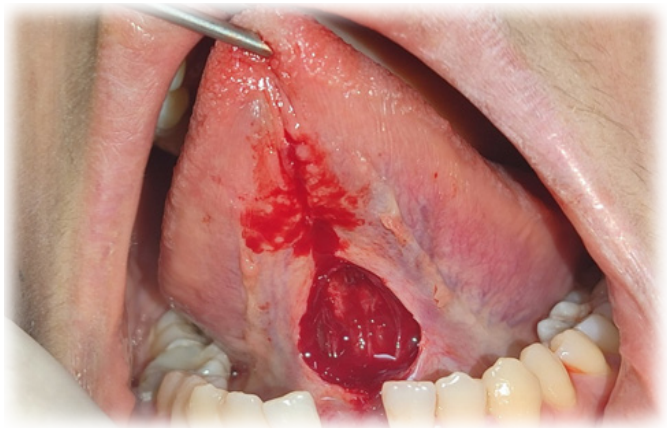

Figure 2. View of the frenulum removed through two incisions on the upper and lower sides of the hemostat

No complications such as numbness or bleeding were observed during the postoperative period. The sutures were removed 10 days after the surgery. The patient stated that she could move her tongue more comfortably and she stated that he could pronounce letters such as 't', 'd', 'r', 'n', 'l', 'r' better (**Figure 4**). No complications were reported during the postoperative and the 6th month follow-up visits, and a successful healing process was observed. The patient was referred to the orthodontic clinic for the treatment of midline diastema, labial displacement, and infantile swallowing pattern.

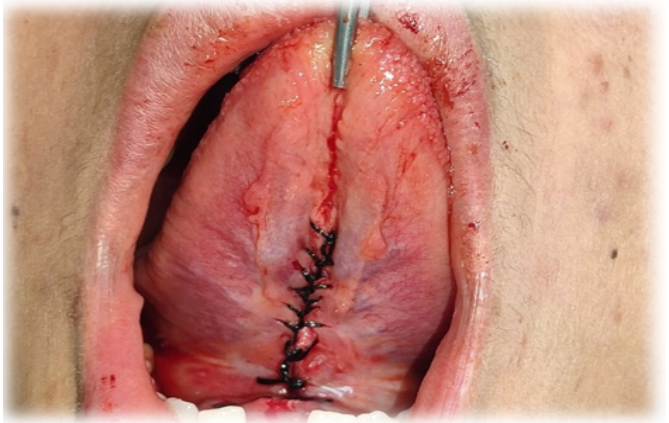

Figure 3. After blunt dissection, suturing the wound with continuous suture technique

Figure 4. Postoperative image of the lingual frenectomy case at the 6-month follow-up

CASE 2

A 19-year-old female patient with difficulty moving her tongue comfortably due to a high frenulum attachment, difficulty pronouncing certain letters, stuttering, and complaining about this condition admitted to the Department of Periodontology at the Faculty of Dentistry, Dicle University. A detailed medical history check revealed no underlying systemic disease.

Clinical examination revealed that this condition led to midline diastema in the mandibular teeth and infantile swallowing pattern, which in turn caused labial displacement of the mandibular anterior teeth (**Figure 5**).

Figure 5. Intraoral view of the high lingual frenulum attachment, ankyloglossia

After a general examination, an informed consent form was obtained, and a lingual frenectomy indication was established. Before the procedure, bilateral lingual block and local infiltrative anesthesia were administered. The frenulum was compressed with a hemostat, and a triangular incision was made using a #15 scalpel. The wound edges were then freed with a blunt dissection, and the wound was sutured using 3/0 sutures with continuous and simple suturing techniques (**Figure 6**). Since the tongue has a strong muscular structure and is a mobile tissue, silk suture with high mechanical resistance and knot security was preferred. During the surgical procedure, attention was paid to the blood vessels, lingual nerve branches, and sub-mandibular salivary gland ducts in the area.

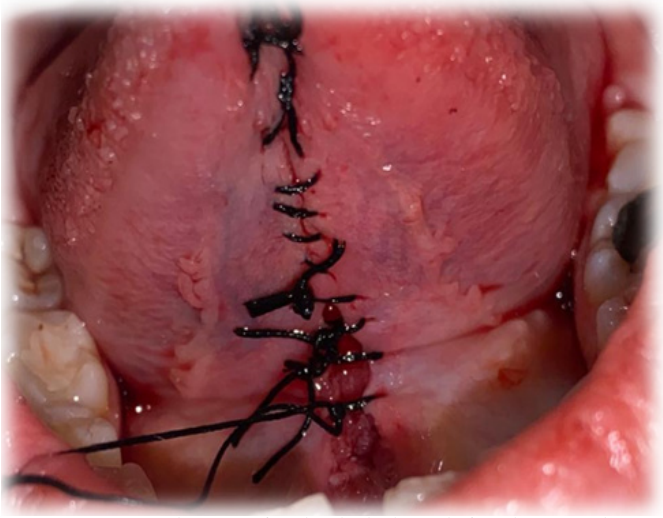

Figure 6. Intraoral view of the high lingual frenulum attachment, ankyloglossia

After the operation, it was recommended to protect the surgical area and avoid activities that may cause bleeding. The patient was prescribed analgesics, anti-inflammatories, and antibiotics postoperatively (Etodolac 400 mg tablet and Amoxicillin/Clavulanic acid 625 mg film tablet for 1 week, and 0.12% chlorhexidine gluconate mouthwash for 2 weeks). The reason for prescribing antibiotics in our cases is to provide a better recovery by preventing surgical site infections, which can be a source of concern in oral surgery due to the high bacterial load in the mouth. The patient's sutures were removed 10 days after the surgery at the follow-up.

No numbness or bleeding complications were observed during the postoperative period. The patient reported that she could move her tongue more comfortably and she stated that he could pronounce letters such as 't', 'd', 'r', 'n', 'l', 'r' better (**Figure 7**). No complications were reported during the postoperative and the 6th month follow-up visits, and a successful healing process was observed. The patient was referred to the orthodontic clinic for the treatment of midline diastema, labial displacement, and infantile swallowing pattern.

DISCUSSION

Ankyloglossia is a congenital anomaly that can cause difficulty in swallowing and speaking.[10] Some studies suggest that ankyloglossia may be a hereditary pathology, but the phenotype and penetrance of genetic components in these patients are not yet understood. Further research is needed to fully understand the etiopathogenesis of ankyloglossia.[11,12]

Figure 7. Postoperative image of the lingual frenectomy case at the 6-month follow-up

It is a common belief that ankyloglossia can affect speech by limiting tongue movement.[13] Messner et al.[14] reported that 71% of children with ankyloglossia had speech difficulties associated with limited oral movement. A recent case report by Verma et al.[15] reported that ankyloglossia causes difficulty in speech and restricted tongue movements. Similarly a study in Taiwan found that 48% of 27 children with ankyloglossia and sleep-disordered breathing had speech difficulties.[16] In our two cases, as in the literature, speech difficulties and challenges in articulating certain sounds were also detected. In addition, in our cases, it was observed that the patient could move his tongue more easily and speak more easily after frenectomy. The effectiveness of frenectomy in improving tongue mobility and alleviating speech and feeding symptoms associated with ankyloglossia has been documented in many studies.[17,18] Saglam et al.[19] successfully treated a 14-year-old boy with speech difficulties using frenectomy followed by speech therap.

Although the lingual frenectomy procedure is simple, but the anatomical structure of the lingual frenum, its proximity to nerves and blood vessels, makes it vulnerable to various intraoperative and postoperative complications. In a review conducted by Varadan et al.,[20] the complications of lingual frenectomy were listed as hemorrhage, retention cyst, ranula formation, sublingual hematoma, infection of sublingual and submandibular spaces, and numbness or paresthesia in the tongue and surrounding tissues. In our two cases, no complications were observed.

Ankyloglossia is a multidisciplinary problem that involves different areas of expertise in dentistry, from periodontology to oral surgery. The normal movement of the tongue is effective in maintaining oral hygiene by cleaning itself. However, in ankyloglossia, the tongue's ability to sweep away food particles is restricted, and adequate mechanical cleaning cannot be achieved. Additionally, it has been reported in the literature that ankyloglossia can cause gingival recession in the lingual direction of the lower anterior teeth, considering these reasons, ankyloglossia is also important for periodontists.[21,22]

CONCLUSION

Ankyloglossia can cause various problems such as speech disorders, feeding difficulties, sleep apnea, psychological and social issues. Therefore, early diagnosis and appropriate surgical intervention can help resolve these problems and contribute to the overall well-being of the patient.

ETHICAL DECLARATIONS

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

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

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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