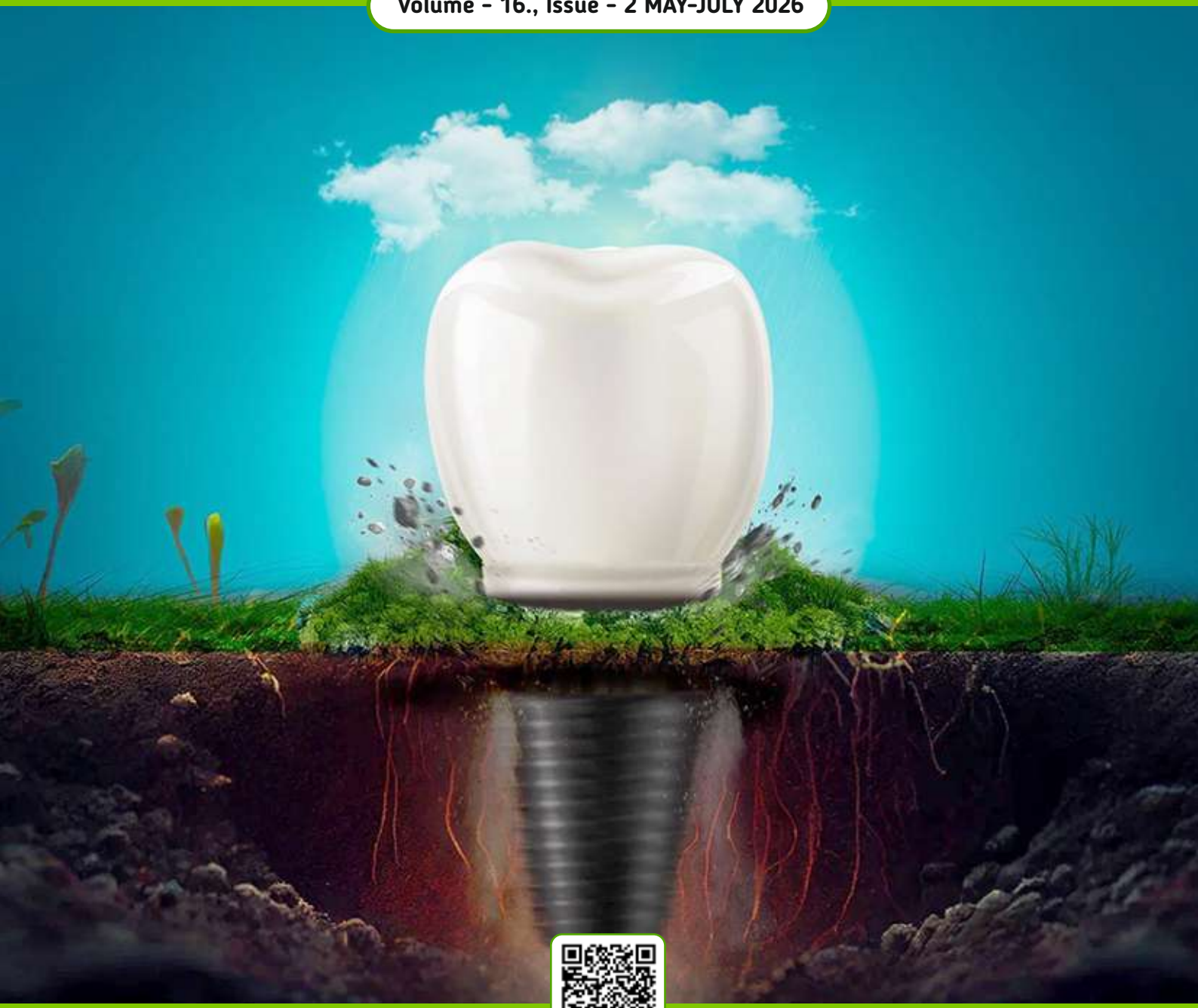
IMPRESSIONS

JOURNAL OF INDIAN DENTAL ASSOCIATION ATTINGAL BRANCH

Volume - 16., Issue - 2 MAY-JULY 2026



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JOURNAL OF INDIAN DENTAL ASSOCIATION ATTINGAL BRANCH

MAY-JULY 2026, VOLUME 16, ISSUE 2.

IDA ATTINGAL BRANCH

IDA Attingal Branch was established on January 14th, 2001. Since then, the branch has symbolized unity. The harmony among its members made the branch popular. Over time, the untiring efforts of eminent office bearers and members reached the branch to its current heights. The branch is always promised to deliver something to the community. Certainly, the plethora of programs organized by the branch over the past two decades has impacted the community's oral health. The branch and its members are always there to share knowledge among the dental fraternity and are the torchbearers of ethical dental practice.

IDA Attingal branch is involved in all the national and state activities of the association with great spirit and won many titles too. The branch organizes a multitude of programs including oral health screening camps, oral cancer detection camps, oral health awareness talks, free denture camps for the needy, continuing dental education programs and workshops for the dentists, training programs for the dental assistants, fun activities for its members, observance of important days, distribution of pamphlets and public awareness materials to the community, spreading awareness talks and videos via various social media platforms, financial support to the poor and a free active dental clinic at an orphanage. The branch is always committed to dental excellence and our journal 'Impressions' is its humble attempt to spread scientific communications among the dental fraternity.

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OFFICE BEARERS

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MESSAGE

Dr. Rakhee Rakesh
President,
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It is with great pride and pleasure that I present my message for the release of the Second Issue of our Dental Journal. The successful publication of this edition reflects the continued dedication, hard work, and academic commitment of our editorial team, authors, and reviewers.

The encouraging response to our inaugural issue has inspired us to further strengthen this platform for scientific exchange and professional development. This journal continues to promote high-quality research, innovative ideas, and evidence-based clinical practice, contributing to the advancement of dental science and education.

I extend my heartfelt congratulations to everyone who has contributed to making this second issue a success. I am confident that our journal will continue to grow in quality, reach, and impact, serving as a valuable resource for dental professionals, researchers, educators, and students.

I convey my best wishes for the continued success of this publication and look forward to many more meaningful contributions in the years ahead.

Dr. Rakhee Rakesh

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MESSAGE

Dr. Vasudevan Vinay
Hon. Secretary,
IDA Attingal Branch

Dear members,

Happy to see another edition of our prized journal in the making. A lot of effort is being put by the editorial team in making this a reality.

The future is digital and IDA is going digital in a big way. The beginning was the launch of IDA Sparsh. Hope all of you would have registered in it by now. A lot of welfare schemes for members and staff were launched by IDA Kerala State this year. Insurance for staff, a discount tie up with DDRC lab, SBI card, Pension plans etc to name a few.

So many schemes. So how do we keep track? All you have to do is send a 'HI' message to 9995009765. All details will be sent to you 24x7. Even the login page of IDA KSB has been made biometric friendly. Just register your fingerprint once and no need to type your login id and password everytime to login.

Hope members make use of these schemes for the benefit of you and your family. As usual the CDE, CDH and WDC wings of IDA Attingal are doing their bit for member knowledge updation and our continuous commitment to society.

Onam is round the corner and our branch will be holding an Onam family get together, the details of which will be announced shortly. Looking forward to seeing you all there and with my advance Onam wishes, secretary is signing out.

Dr. Vasudevan Vinay

AUTHOR GUIDELINES

About the Journal : Impressions is the official scientific publication of IDA Attingal Branch, which publishes in every four months period.

Aims and Scope : The aim of Impressions is to publish all forms of scientific articles including systematic reviews, original articles, case reports, and review articles pertaining to dentistry. Those articles bring new knowledge to the field are welcomed.

Ethical Considerations : Manuscripts submitted for publication must comply with the following ethical considerations: Written informed consent must be obtained from the subjects before their data included in the study and the informed consent must be archived with the authors. Any data from the patient must be submitted by hiding their identity. All the research should be carried out with prior approval from the institutional or national ethics committee and should be in accordance with the Helsinki Declaration of 1964 (revised in 2008). If animals are using for the research, the authors must follow the institutional or national guidelines for the care of use of laboratory animals.

Manuscript Submission : All the manuscripts should be in English language and are to be submitted electronically at:journalidaatl@gmail.com The manuscript must be original and submitted only to Impressions.

Manuscript format :

Title : The title must be clear, specific, and informative.

Abstract : Must include an abstract of not more than 250 words that describe the significance of the article.

Manuscripts : The manuscripts should be of maximum of 3500 words excluding the references.

Illustrations : High-quality digital images must be submitted with a file name matching the manuscript reference.

References : References must be included and the bibliography should follow the Vancouver format.

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CONTENTS

IMPRESSIONS
JOURNAL OF INDIAN DENTAL ASSOCIATION ATTINGAL BRANCH

EDITORIAL

Dr. Nripan. T
Editor-in-Chief
Impressions

Bridging Innovation and Intuition in Modern Practice

The rapid rise of digital workflows, diagnostic AI, and bioactive materials is fundamentally redefining modern dentistry. Precision tools like intraoral scanning, 3D printing, and guided surgery have made predictable care routine, while smart biomaterials actively remineralize tooth structure to support minimally invasive practice.

Yet, technology remains an amplifier—not a replacement—for clinical judgment. While machine learning can flag subtle radiographic lesions, only the clinician can tailor care to human context and anatomical reality.

As members of IDA Attingal, our goal is to marry these advances with sound evidence and empathetic practice. In this issue of Impressions, we share insights to help you navigate these innovations with confidence and clinical discernment.

Dr. Nripan. T

EVALUATING THE EFFECTIVENESS OF LARGE LANGUAGE MODELS BASED AI CHATBOTS IN ADDRESSING PATIENT RELATED QUERIES REGARDING DENTAL TRAUMA AND IT'S RELATED CONDITIONS

[1] **Neha Parveen**

ABSTRACT

Traumatic dental injuries (TDIs) require rapid, accurate decision-making to prevent irreversible complications, yet public health literacy remains limited. This study evaluated the performance of large language model (LLM)-based AI chatbots in responding to patient-related queries regarding dental trauma.

INTRODUCTION

Large language models (LLM) are AI systems trained on massive datasets using advanced machine learning algorithms, these models excel at understanding and generating human like text , enabling them to provide accurate and coherent information across a wide range of topics. Patients often find inconvenience to approach Your paragraph text their treating physicians with minor concerns due to need for frequent visits and long wait times to see the surgeons, Here we are going to access and evaluate different LLM (Large language models) for Frequent Asked Questions (FAQs) directly from the patients and also from different search engines (eg. People also ask.com)

This article provides a brief about the following points:

1. Evaltion of multiple AI chatbots clinically.
2. Uses a standardized assessment framework QUEST
3. Focuses on oral and maxillofacial surgery patients communication
4. Highlights both interest and limitations of AI in dentistry and surgery
    1. To study their usefulness in emergency dental trauma situations
    2. To access agreement with international Association of Dental Traumatology (IADT) guidelines

Although these systems generate Human like responses, concerns remains regarding the accuracy, safety and clinical reliability of the

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How to cite this article : Parveen N. Evaluating the effectiveness of large language models based AI chatbots in addressing patient related queries regarding dental trauma and it's related conditions. Impressions. 2026;16(2):10-12.

Source of support : Nil,

Conflict of Interest : None declared.

information provided particularly in emergency condition like dental trauma . Inaccurate guidance may lead to delayed treatment or inappropriate self management, potentially worsening clinical outcomes

PURPOSE

Large language models (LLM) improve clinical knowledge , supports decision making and also assisting in academic and research activities LLM based conversational agents can mimic human interaction in resolving medical queries of the general public . In today's era internet is most easily accessible platform for attending all types of queries . Mostly young patient increasing turns to LLM platforms for health care informations .Hence there is a great need to improve the AI based models to generate pateint friendly medical information as the wrong answers can misguide the patient and further complicate the situation . Recently , Large language models (LLM) based artificial intelligence chatbots such as Open AI chatgpt, Google Gemini and Microsoft copilot have become widely accessible tools for health related queries.

Methodology Study Design

Cross sectional observational comparative study

Study Duration 1-2months

Selection of AI chatbots and models compared

DOT-1=Chat gpt DOT-2 =LLaMA

MTM=Gemini PM=Microsoft copilot CAM=claude AI

DEVELOPMENT OF QUESTIONNAIRE

A set of 40-50 standardized patient oriented questions developed based on Avulsion injuries, Crown/Root fractures, Luxation injuries, Soft tissue injuries, post trauma instructions, Emergency management steps Data collection Procedure.

Each question entered individually into all selected AI chatbots under identical conditions And the responses were recorded Responses were blindly evaluated by experts (consisting of surgeons and JRs and SRs) using the quest framework Parameters Assessed-(Accuracy Hallucinations Usefulness Clarity Trustworthiness Safety Satisfaction

Readibility (Flesch-kincaid scores)

Scoring systems : A 5 point Likert scale will be used 1=Very Poor, 2=Poor, 3=Average, 4=Good, 5= Excellent

Key results : The study is expected to demonstrate variability in the quality of response generated by different LLM based AI chatbots. It is anticipated that newer models like chatgpt provides more structural and clinically relevant answers compared to other platforms, although occasional inaccuracies or oversimplification of emergency protocols may still be observed. It is also observed that while most chatbots provide generally understable responses clinical precision in emergency dental trauma management may not always align fully with established guidelines such as those of the international Association of Dental traumatology-

Best overall performance

Chatgpt (DOT-1) : performed the best overall Highest accuracy 88.5%. Lowest hallucinations 5.2%, Highest usefulness, clarity, trust and satisfaction scores Claude

AI(CAM) : Accuracy closest to chat gpt 86%. But responses were too difficult for average patients to understand because readability level was too high

Gemini (MTM) : Intermediate performance with moderate scores in most categories

LLaMA and Copilot : Lower accuracy and highest hallucinations compared to chatgpt

Findings : Although chatgpt provides mostly accurate information, all models produced responses were too complex for average patients as per the literacy rate of patients attending opds None achieved the readability level of the patient education

DISCUSSION

The increasing use of AI based conversational agents has transformed access to health information. Dental trauma, being an emergency condition requiring an immediate decision making ,is particularly sensitive to the quality of information provided to patients Previous studies in medical and dental field suggest that LLMs demonstrate high fluency and general accuracy but may occasionally produce incomplete or outdated recommendation this raises concerns when such tools are used without professional supervision. A key strengths of this study is its focus on real world patient queries, making the findings clinically relevant. The comparison between multiple AI platforms also helps identify consistency and variability in responses . However limitations include rapid updates in AI models which may change performance over time and the subjective nature of expert based evaluation . Despite these limitations, AI chatbots hold promise as supportive educational tool rather than replacement for professional dental consulation.

Their Integration with verified clinical guidelines could improve patients awareness and emergencies response

CONCLUSION

LLM based AI chatbots demonstrate considerable potential in providing preliminary information on dental trauma and associated conditions. However variability in accuracy and clinical reliability highlights the need for cautious use. These tools should be considered adjuncts for patients education rather than substitute for professional dental advice

Conclusion 1 : AI chatbots can help in patient education.

1. Chatgpt shows the strongest performance overall

2. However, Clinical supervision is still necessary. because AI may provide Inaccurate or difficult to understand information.

3. Future AI systems should focus on generating more patient friendly explanations.

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EVALUATING THE TRANSITION TO INDEPENDENCE: SELF-ASSESSED CLINICAL COMPETENCE AND GAPS IN A NORTH INDIAN DENTAL COLLEGE

[1] Ritika, [2] Orooj Fatima , [3] Sabzar Abdullah

ABSTRACT

Background: The transition from classroom learning to independent clinical practice is a critical phase in dental education. This study aims to evaluate the self-assessed preparedness among dental students and interns at an institution in North India, focusing on their confidence in manual skills and clinical decision making.

Methods: A study was conducted among final year students of Bachelor of Dental Surgery (BDS) and Compulsary Rotatory Interns. Preparedness was assessed using the **Dental Undergraduates Preparedness Assessment Scale (DU-PAS)**, which evaluates 31 items related to diagnostic,clinical manual skills and behavioral attributes. Data were analysed to identify specific strengths and weaknesses within the local training environment.

Results: Participants showed high confidence in routine tasks such as obtaining consent, and performing basic restorative treatments. However, noteworthy experience gap was seen in complex endodontic, cast dentures, and crown placement. Behavioral competencies, specifically pediatric management and drug prescription, needed assistance. Notably, many responders lacked experience in the critical area of referring suspected oral cancer.

Conclusion: While the curriculum successfully builds foundational competence, a "preparedness gap" exists in specialised procedures and ontological screening. To ensure professional freedom, the institution should priorotize supervised exposure to complex clinical scenarios and advanced diagnostic protocols.

Keywords: Self-assessed, clinical assessment, diagnostic assessment, dental undergraduate students, dental interns.

INTRODUCTION

The transition from undergraduate dental education to independent clinical practice is considered a critical phase in dental training. Dental graduates are expected to possess adequate clinical competence, communication skills, professionalism, and decision making ability to manage patients independently after graduation. However, several studies have reported that although dental students demonstrate confidence in routine clinical procedures, deficiencies continue to exist in advanced clinical skills and independent patient management [1,3,4].

Studies conducted in Saudi Arabia, Poland, Malaysia, Pakistan, Turkey, Oman, and the United Kingdom have shown that dental students are generally confident in procedures such as oral examination, restorative treatment, administration of local anesthesia, and communication with patients. However, lower confidence levels have consistently been reported in advanced endodontic procedures, prosthodontic procedures, orthodontic assessment, pediatric patient management, prescription writing, and oral cancer referral [3,4,5,6].

In a similar finding, Gaballah et al. noted that there were differences in assessments by faculty and perceptions by patients on the clinical competence of dentists, stressing the need for competency-based evaluation approaches in teaching dental students [1]. Almahdi et al. found that KFU dental graduates had confidence in performing routine tasks but needed improvement in performing complex tasks and patient management [2]. Likewise, Javed et al. reported that the final year dental students/interns from Saudi Arabia had low confidence levels in performing difficult clinical procedures and making decisions independently [4]. Jankowski et al. further reported that there were some areas of unpreparedness among Polish dental graduates, such as prosthodontic procedures, multi-rooted endodontic treatments, prescription writing, and referral for oral cancer patients [5]. The importance of adequate exposure and competency-based evaluation was highlighted in research from Malaysia and Turkey [6].

There can be variations in preparedness levels of dental graduates due to various factors including exposure to clinical experiences, supervision by the faculty, institutional infrastructure, and number of patients. Only a few studies have been conducted on the preparedness of dental undergraduate students/interns in India.

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How to cite this article : Ritika, Fatima O, Abdullah S. Evaluating the transition to independence: Self-assessed Clinical Competence and Gaps in a North Indian Dental College. Impressions. 2026;16(2):13-17.

Source of support : Nil,

Conflict of Interest : None declared.

Therefore, this study aims to evaluate the self-perceived preparedness levels of final-year dental students and interns in a dental college in North India.

Materials and methods

Study design and participants

A cross-sectional questionnaire-based study was conducted among final-year Bachelor of Dental Surgery (BDS) students and Compulsory Rotatory Interns at a dental college in North India. A modified Dental Undergraduates Preparedness Assessment Scale (DU-PAS) questionnaire consisting of 31 items was circulated through Google Forms to assess students' self-perceived preparedness for independent clinical practice. Participation was voluntary, and informed consent was obtained from all participants before data collection.

Inclusion Criteria

- Final year BDS students
- Dental interns undergoing compulsary rotatory internship
- Students willing to participate in the study

Exclusion Criteria

• Incomplete questionnaire

Study Instrument

Preparedness was assessed using a modified version of the Dental Undergraduates Preparedness Assessment Scale (DU-PAS). The questionnaire evaluated multiple domains including:

Clinical manual skills

1. Diagnostic abilities
2. Communication and professionalism
3. Patient management
4. Competencies in Behavioral Skills & Ethics
5. Participant's self-confidence and independence in doing particular procedures was measured based on a questionnaire with structured responses.

Data Collection

Data collection was done through the distribution of questionnaires in Google Forms to the final-year BDS students and interns. The participation was completely voluntary and anonymous. Data collected from participants was later analyzed to find out strengths and weaknesses.

RESULTS

Respondent's Characteristics

Respondent for this survey consisted of fifty dental trainees who include the final-year Bachelor of Dental Surgery (BDS) students and Compulsory Rotatory Interns from one dental institute located in North India.

These respondents constitute the main clinical workforce towards becoming a professional. In terms of their gender, the predominant sex in the sample was female as is seen today among enrolled students in regional dentistry.

Clinical and Diagnostic Preparedness

The OBE analysis of the 31-item survey has identified a hierarchical structure based on the self-assessment of clinical competence. The respondents showed the greatest level of professional independence in terms of diagnostic and operatory knowledge areas. In particular, 90.0% of the respondents believed that they could carry out an independent medical history and 84.0% claimed that they have mastered the skill of conducting comprehensive clinical oral examination.

The skill of conducting dental X-rays proved to be well-developed among the respondents – 80.0% claimed that they had the ability to independently interpret the usual dental radiographic finding, and 54.0% considered themselves independent in prescribing appropriate dental radiographs. As regards manual skills, tooth-colored restorations were identified as the main area of competence of 88.0% of the trainees.

Competencies in Behaviors and Ethics

High to moderate levels of mastery of professional and ethical competence were observed among all respondents. Most of the respondents (68.0%) stated that they ensured

confidentiality of their patients. Professional competencies, which include taking accurate clinical notes, getting assistance when required, and having an understanding of legal issues, scored 62.0% mastery level. Also, 56.0% of the respondents were confident that they could obtain valid consent from their patients.

Identified Technical and Diagnostic Gaps

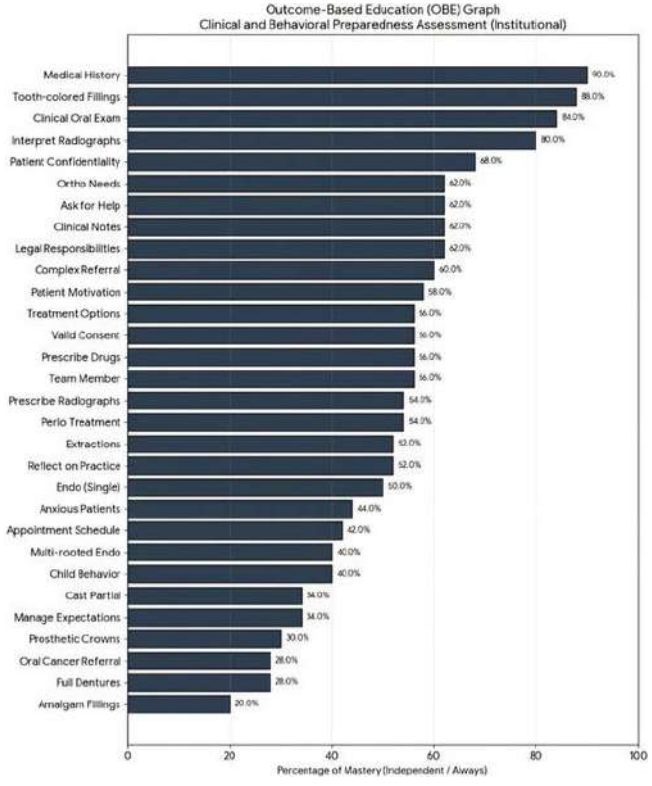
Significant experience gaps were identified in technically demanding and specialized clinical protocols. The independent mastery of multi-rooted endodontic treatment was achieved by

40.0% of the participants, while 30.0% felt capable of independently providing prosthetic crowns. Technical skilfulness was lowest in restorative procedures involving full dentures (28.0%) and amalgam fillings (20.0%).

The most critical diagnostic deficiency observed was the referral of suspected oral cancer, where only 28.0% of respondents felt capable of "always" performing this task confidently. Additionally, specialized patient management remained a challenge; only 40.0% of trainees reported the ability to independently manage the behavior of pediatric patients during treatment.

Outcome-Based Education (OBE) Mastery Levels

The relative levels of independent mastery across all evaluated criteria are visualized in the given Figure, ranking the institutional output from established clinical proficiencies to critical preparedness gaps.



DISCUSSION

This current study investigated the self-reported readiness of last-year dental students and interns towards clinical independence. The majority of respondents felt prepared to undertake normal clinical activities such as oral examinations, giving local anesthetics, restorations, and extractions without surgery. The same results have been found in previous studies conducted in Saudi Arabia, Malaysia, Poland, Turkey, and the United Kingdom[2,3,4,5,6].

The respondents also showed high levels of readiness regarding communication and professionalism, such as informed consent and patient confidentiality [1,3,5]. On the other hand, they felt less confident regarding endodontics treatment, prosthodontic treatment, pediatric patients, writing prescriptions, and referral of oral cancer suspect patients[2,4,5].

Intuitively, the interns had more confidence compared to the last-year students probably because of greaterclinical experience in the course of internship training[4,5].

These results imply that undergraduate dental education adequately prepares students for routine dental procedures but needs improvement in terms of greater focus on advanced clinical procedures training and competency-based approach to training. The study suffered from small sample size and self-assessment only.

CONCLUSION

From the above discussion, it can be concluded that both final year dental students and interns had adequate confidence in terms of routine dental procedures and communication. However, preparedness problems existed regarding advanced dental procedures, management of pediatric cases,

prescription writing, and referral of suspected cases of oral cancer.

These observations highlight the necessity for better clinical preparation, competency-based approach, and professional supervision during undergraduate dental education.

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DENTIN THICKNESS IN MANDIBULAR MOLARS USING MICRO-CT: A CROSS-SECTIONAL STUDY IN INDIA

[1] Fadila Khan, [2] Sajid Ali

ABSTRACT

This study investigates dentin thickness on the mesial wall, considered the safety zone, and the distal wall, regarded as the danger zone, of mesiobuccal and mesiolingual canals in mandibular molars. A total of eighty mandibular molars from Indian subjects were examined. Micro-computed tomography (micro-CT) scans were performed at a high resolution of 10 micrometers, allowing for detailed visualization of internal structures. Cross-sectional images, taken below the furcal level, were analyzed to measure dentin thickness accurately at specific points. The distance from the mesiobuccal and mesiolingual canals to the external surface of the root on both the mesial and distal aspects was measured. Descriptive statistical methods were employed to analyze the measurements, providing detailed insights into the variations in dentin thickness on both sides. Results show that the danger zone corresponds to a dentin thickness of 1.05 mm or less. The dentin thickness located 4 mm below the furcation ranges from 0.56 to 1.43 mm, with an average of 1.05±0.23 mm in the MB canal, and varies from 0.60 to 1.70 mm, averaging 1.05±0.25 mm in the ML canal on the distal wall. On the mesial wall at the same level, the thickness ranges from 1.06 to 1.87 mm, with an average of 1.39±0.18 mm in the MB canal and 1.37±0.27 mm in the ML canal. The findings indicate that the entire region of the distal wall, located 3 mm below the furcation, should be regarded as a hazardous zone in mandibular molars. It is essential to recognize the significance of a 0.3 mm difference as a critical factor in the prevention of perforations.

Keywords: Dentin thickness, India, mandibular molars, Micro-CT, Mesial root.

INTRODUCTION

A crucial factor in the treatment success is the preservation of dentin thickness, especially in areas susceptible to iatrogenic damage during biomechanical preparation. The distal aspect of mesial roots, termed the "danger zone" (DZ), is especially vulnerable as dentin thickness in this area is limited.[2] The excessive removal of dentin in this area during shaping or post space preparation can lead to strip perforations, compromising prognosis of endodontic treatment.[3-5] Conversely, the mesial aspect of these roots,

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How to cite this article : Fadila K, Sajid A. Dentin thickness in Mandibular Molars using Micro -CT: A Cross-sectional Study in India . Impressions. 2026;16(2):18-23.

Source of support : Nil,

Conflict of Interest : None declared.

with thicker dentine is termed the "safety zone" and is less impacted by endodontic instrumentation.

Root canal anatomy in mandibular molars involves a maximum preparation depth of 1 mm in molars located 6 -7 mm below the furcation, with a higher risk of perforation occurring at 5-6 mm apical to the furcation. Endodontic treatment faces significant challenges due to the variability and complexity of these structures. Techniques to evaluate dentin width (DZ), including tooth sectioning, radiography, and Cone Beam Computed Tomography (CBCT), each have inherent limitations. Tooth sectioning is destructive; radiographs provide only 2D images and tend to overestimate dentin thickness; CBCT is limited by low resolution. Recent advances with micro-CT have allowed detailed, high-resolution 3D mapping of root canal morphology without damaging specimens. Although some micro-CT studies have investigated DZ thickness in mandibular molars, detailed morphological analysis remains inadequate. Previous studies only measured a few root slices; given the complexity of canal anatomy, analyzing more sections is essential for accurate assessment of DZ location and dimensions. The intricate anatomy of mandibular molars characterized by thin dentinal walls poses a significant challenge to successful endodontic treatment. Perforations, particularly within the "danger zones" of these teeth can lead to treatment failure. Therefore, understanding the dentin thickness variations and identifying danger zones is crucial for safe and effective instrumentation. The present study evaluated dentin thickness along the root surface from the furcation to the apical third of the root.

MATERIALS AND METHODS

Sample collection and preparation

A total of 80 mandibular first and second molars were collected after extraction. Teeth with previous endodontic treatment, restorations, carious lesions, resorptions, or defects were excluded. Teeth were cleaned to remove soft tissue remnants with an ultrasonic instrument. The collected teeth were sterilized in 5.25% sodium hypochlorite solution before storage in saline until further use.

Micro-CT imaging

Teeth were scanned using a high-resolution desktop micro-computed tomographic unit (mCT-50; Scanco Medical, Bassersdorf, Switzerland) at pixel size of 10µm, 90 kV, 200mA, camera exposure duration of 600 ms, complemented by a 0.1 mm aluminum filter. A rotational step of 0.1° was maintained for a under 180° rotation, generating approximately for each specimen after processing.

Image Analysis

A comprehensive analysis was performed on the TIFF image dataset. For each specimen, approximately 600-800 cross-sectional images were carefully selected at intervals of every millimeter, from 1 mm to 7 mm apical to the furcation level of the mandibular molar teeth. ImageJ software was utilised to accurately measure dentin thickness in the mesial and distal walls. A single observer measured the distance between the mesiobuccal and mesiolingual canals and the external surface of the root on both the mesial and distal sides. When the difference between measurements exceeded 0.05 mm, a second assessment was carried out. This process was repeated, blind to the initial results, with the average of the two measurements recorded after a four-week interval.

Statistical Analysis

Statistical analysis was done using IBM SPSS software version 20. The Shapiro-Wilk test

was carried out to assess the normality distribution ($p>0.05$), while descriptive statistics were applied to determine the dentin thickness, expressed in terms of mean and range.

RESULTS AND DISCUSSION

The distal wall was considered a danger zone if the dentin thickness was ≤1.05mm. At the 3-4mm level below furcation, the distal wall thickness ranged from 0.56-1.43mm (mean 1.05±0.23mm) in the MB canal and 0.60-1.70mm (mean 1.05±0.25mm) in the ML canal. The distal wall thickness progressively decreased from the furcation towards the apex in both canals. The measurements are given in Table 1a.

At the 3-4mm level below furcation, the mesial wall thickness ranged from 1.06-1.87mm (mean 1.39±0.18mm) in the MB canal and 0.97-1.80mm (mean 1.37±0.27mm) in the ML canal. As with the distal thickness, the mesial thickness also progressively decreased from furcation towards the apex as illustrated in Table 1b.

A study reported by Lee et. al, 2014 using high resolution with 0.01mm slice interval was found to be the only previous micro-CT study conducted at this resolution.[8] To prevent strip perforation, Berutti and Fedon claimed that deviations of tens or hundreds of millimeters are crucial.[10] The present study evaluated the dentin thickness on the root surface at a high resolution 0.01 mm revealed the same findings. These measurements were mostly derived from investigations using a stereomicroscope and other sectioning methods. CBCT studies with low spatial resolution and micro-CT studies showed measurements obtained only 1.5 mm below the furcal area.[7,13-15] The present study evaluated dentin thickness along the root surface from the furcation to the apical third of the root and revealed the thinnest wall located 7 mm below the furcation.

Previous micro-computed tomography studies of the mandibular first molar quantitatively investigated the morphology and indicated that the furcal aspect of the entire mesial root should be considered a "danger zone," which is following the present study.[7] This finding was also supported by a recent study reporting the location of the danger zone below the furcation range of 4.37±1.68 mm.[3] Not following this anatomy and overly aggressive preparation at 6 mm below the furcation can lead to strip perforation and increased complexity during treatment.

Table 1a: Dentin thickness measurement in millimeters in distal wall at 1-7mm below furcation

Level below furcation	1-2		2-3		3-4		4-5		5-6		6-7	
	MB	ML	MB	ML	MB	ML	MB	ML	MB	ML	MB	ML
Mean±SD	1.32± 0.26	1.23± 0.24	1.18± 0.25	1.12± 0.25	1.05± 0.23	1.05± 0.25	1.03± 0.22	1.01± 0.26	1.03± 0.22	0.98± 0.25	1.02± 0.21	0.95± 0.23
Range	0.59- 1.91	0.68- 1.93	0.57- 1.84	0.60- 1.72	0.56- 1.43	0.60- 1.70	0.57- 1.43	0.41- 1.65	0.57- 1.42	0.36- 1.58	0.44- 1.43	0.36- 1.45

Table 1b: Dentin thickness measurement in millimeters in mesial wall at 1-7mm below furcation

Level below furcation	1-2		2-3		3-4		4-5		5-6		6-7	
	MB	ML	MB	ML	MB	ML	MB	ML	MB	ML	MB	ML
Mean±SD	1.63± 0.21	1.60± 0.25	1.51± 0.21	1.48± 0.24	1.39± 0.18	1.37± 0.27	1.30± 0.17	1.30± 0.17	1.23± 016	1.23± 0.19	1.19± 0.17	1.15± 0.18
Range	1.27- 2.20	1.14- 2.12	1.13- 2.06	1.05- 1.87	1.06- 1.87	0.97- 1.80	0.99- 1.92-	093- 1.65-	0.93- 1.63-	0.80- 1.60-	0.75- 1.69-	0.78- 1.60-

In the current study, dentin thickness on the mesial wall was consistently greater than 1mm (1.39 mm for mesiobuccal and 1.37 mm for mesiolingual canals) even at 7mm below the furcation, contrasting with previous studies reporting mid-root perforations in this area during biomechanical preparation.[11] Another study[16] further support this as it challenges the conventional "danger zone" concept, indicating that mesial canals are more deviated towards the mesial aspect of the roots than the distal aspect. This difference could be attributed to the sample size and ethnicity of the studied population. Further studies should investigate whether the increased thickness observed translates to a genuinely safer zone during canal instrumentation.

Recent instrumentation advocates the use of a crown-down technique with the use of Ni-Ti instrumentation to improve cleaning, shaping, and minimize procedural errors such as over-instrumentation, as this will increase postoperative pain. Coronal flaring enlarges the cervical and

middle-third areas of the root canal, facilitating tactile control of instruments in the apical third.[17,18] Conversely, excessive removal of dentin in this concave zone leads to additional challenges and difficulties during treatment.[19] The amount of dentin presents for a safety allowance range 0.5-1 mm.[20,21] Hence, the maximum coronal enlargement should not be more than 1.5 mm as the safety zone maximum thickness is approximately 2.02 mm.

According to one study using CBCT, the distal concavity of the mesial root of mandibular first molars is thinner in longer teeth than in shorter teeth, both at the furcation point and at the intersection of the apical and middle thirds of the roots.[22] In contrast, the present study revealed findings with progressively decreasing dentin thickness at the distal wall starting from the furcal point towards the apical area.

Further studies must be performed to validate this finding with a known age, considering that intracanal deposition of dentine with age may also affect the position and thickness of the DZ.[23] In addition to these limitations, the present study innovates by adding important information on dentin thickness on the root surface below 7 mm of furcation on a previously established DZ, which reported evaluating only certain cross-sectional images and determined that the entire aspect below 3 mm should be considered a danger zone. The DT in mesial wall range 1.06-1.87 mm with average of 1.39±0.18 mm, at 3-4 mm below furcation and the least dentin thickness was 0.78 mm. The differences between the mesial and distal wall ranging 0.25-0.3 mm. This finding leads to the understanding that the mesial side of the mandibular molars is a safe area for biomechanical preparation.

CONCLUSION

This study found dentin thickness was more than 1.05mm upto 3 mm from furcation and beyond 3 mm it was less than 1.05 mm in the distal wall of both MB and ML canals. It shows that the entire distal wall beyond 3 mm is prone perforation during endodontic instrumentation. Additionally, it was found that especially in ML canals dentin thickness beyond 5 mm to apex was very thin which is 0.36 mm, further heightened the risk of strip perforation. This corroborates with the previous study by Lim and Stock[6], which identified 0.3 mm as the minimum canal wall

thickness that must remain after instrumentation to prevent perforation or vertical root fracture. This specific region warrants modification during biomechanical preparation. The least dentin thickness in ML canal can be attributed to the increased inner curvature of the mesial root. Hence, Anticurvature filing directed on its outer aspect towards mesial side is

recommended in the mesial root of the mandibular molars.

With the limitations of the study, the entire aspect of the distal wall of mesial root 3 mm below the furcation should be considered a danger zone in mandibular molars. Consider the difference of 0.3mm as the important factor to prevent perforations. The maximum coronal preparation should not exceed 1.5mm in mandibular molars till 6 mm below furcation on the mesial wall. In distal wall of ML canal, there is higher chance of perforation below 5mm from furcation.

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THE RELATIONSHIP BETWEEN NON-METRIC DENTAL TRAITS AND EARLY MENARCHE: A NARRATIVE REVIEW

[1] Siya K

ABSTRACT

Developmental stress during childhood can influence multiple biological systems, including craniofacial growth, dental development, and pubertal maturation.[1] Teeth are considered as one of the valuable biological archives because they preserve evidence of environmental and physiological disturbances occurring during developmental stage.[2] Non-metric dental features and developmental dental defects have increasingly gained attention as potential markers of developmental instability and stress. Early menarche, a marker of accelerated pubertal maturation, has also been associated with nutritional, hormonal, psychosocial, and environmental factors experienced during childhood.[1] This review explores the possible association between non-metric dental traits, developmental stress, and early menarche. The article discusses the developmental basis of dental traits, mechanisms linking developmental stress with pubertal timing, and the relevance of dental anthropology in identifying biological stress markers. Understanding this relationship may contribute to interdisciplinary research involving dentistry, anthropology, endocrinology, and public health.

Keywords: Non-metric dental traits, developmental stress, early menarche, enamel hypoplasia, dental anthropology, pubertal maturation

INTRODUCTION

Human growth and development are always influenced by a complex interaction between genetic, environmental, nutritional, and hormonal factors. During childhood, exposure to stress either physiological or psychosocial can alter normal developmental pathways, leading to measurable changes in different tissues and organ systems.[1] Teeth are particularly valuable in developmental studies because dental tissues, once formed, remain relatively stable throughout life and permanently record disturbances that occur during odontogenesis.[2]

Non-metric dental traits are qualitative morphological variations observed in the dentition. These include traits such as shovel-shaped incisors, Carabelli cusp, talon cusp, peg laterals, cusp number variations, and enamel hypoplasia. While many of these traits are genetically determined,

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How to cite this article : Siya K, The Relationship Between Non-Metric Dental Traits and Early Menarche: A Narrative Review. Impressions. 2026;16(2):24-28.

Source of support : Nil,

Conflict of Interest : None declared.

certain developmental dental defects may reflect environmental stress during growth.[1]

Menarche, the onset of menstruation, is a major milestone in female pubertal development.[3] In recent decades, a secular trend toward earlier menarche has been observed worldwide. Early menarche has been linked to improved nutrition, obesity, endocrine changes, psychosocial stress, and environmental exposures. Researchers have suggested that childhood developmental stress may influence pubertal timing through neuroendocrine pathways.

The potential relationship between developmental dental markers and early menarche represents an emerging interdisciplinary field of interest. This review aims to evaluate existing evidence regarding non-metric dental features as indicators of developmental stress and their possible association with early menarche.[4]

Developmental Stress and Human Growth

Developmental stress refers to disturbances occurring during prenatal or postnatal growth that disrupt normal biological development. Such stress may arise from:

- Malnutrition
- Chronic illness
- Hormonal imbalance
- Psychosocial adversity
- Environmental toxins
- Socioeconomic deprivation

The body responds to developmental stress through adaptive physiological mechanisms. However, prolonged or severe stress may result in developmental instability, characterized by deviations from normal growth patterns.5 Developmental instability may manifest in skeletal structures, dentition, and pubertal maturation.

Because teeth develop over a prolonged period and mineralize incrementally, they serve as reliable indicators of stress experienced during childhood.

Non-Metric Dental Features

Non-metric dental traits are morphological variations that are usually assessed visually rather than through direct measurements. These traits are widely used in dental anthropology, forensic odontology, and population studies.[6]

Common non-metric dental features include:

- Shovel-shaped incisors
- Carabelli cusp
- Talon cusp
- Protostylid
- Peg-shaped lateral incisors
- Cusp number variations
- Groove patterns
- Enamel pearls
- Supernumerary cusps

Most non-metric traits are genetically influenced; however, their expression may also be modified by environmental and developmental factors. Increased developmental instability may alter the expression or symmetry of certain dental features.

Dental Indicators of Developmental Stress
Enamel Hypoplasia

Enamel hypoplasia is one of the most widely studied dental markers of developmental stress. It appears as pits, grooves, or linear defects in enamel caused by disruption of ameloblast function during tooth formation.

Etiological factors include:

- Nutritional deficiencies
- Infectious diseases
- Fever episodes

- Metabolic disorders
- Psychological stress

Because enamel cannot remodel after formation, hypoplastic defects permanently preserve evidence of childhood stress exposure.[6]

Fluctuating Asymmetry

Fluctuating asymmetry refers to small random deviations from perfect bilateral symmetry. Increased asymmetry in dental structures may indicate developmental instability resulting from environmental stressors.

Delayed or Accelerated Dental Development

Stress-related endocrine disturbances may influence the timing of tooth eruption and mineralization patterns.

Early Menarche and Developmental Influences

Menarche generally occurs between 11 and 14 years of age, although the timing varies among populations. Early menarche is commonly defined as onset before 12 years of age.

Several factors influence pubertal timing:

- Genetics
- Nutritional status
- Body mass index
- Childhood obesity
- Psychosocial stress
- Endocrine-disrupting chemicals
- Socioeconomic conditions

Early maturation has been associated with long-term health consequences including:

- Obesity
- Type 2 diabetes
- Cardiovascular disease
- Breast cancer risk
- Psychological disturbances

Recent studies suggest that childhood stress may activate neuroendocrine pathways involving the hypothalamic-pituitary-gonadal axis, potentially accelerating pubertal maturation.[7]

Possible Biological Link Between Dental Features and Early Menarche

The relationship between non-metric dental features and early menarche may be explained through shared developmental pathways influenced by environmental stress.

Hormonal Influence

Hormones involved in growth and puberty also influence craniofacial and dental development. Alterations in endocrine function during childhood may therefore affect both dental morphology and pubertal timing.

Nutritional Factors

Nutritional status plays a major role in both enamel formation and menarcheal timing. Childhood malnutrition may produce enamel defects, while overnutrition and obesity are linked to earlier menarche.

Developmental Instability

Individuals exposed to developmental stress may demonstrate both dental developmental anomalies and altered pubertal maturation patterns.

Genetic and Epigenetic Factors

Genes regulating growth, mineralization, and endocrine function may contribute to both dental trait expression and reproductive maturation. Environmental stress may further modify these pathways through epigenetic mechanisms.[8]

Current Evidence

Research directly correlating non-metric dental traits with early menarche remains limited.

However, multiple studies independently support:

- The use of dental defects as markers of developmental stress
- The association between childhood stress and altered pubertal timing

Anthropological studies have demonstrated increased enamel hypoplasia in populations exposed to nutritional and environmental stress. Similarly, epidemiological research has linked psychosocial adversity and childhood obesity with earlier menarche.

The integration of dental anthropology with reproductive developmental studies may therefore provide novel insights into biological stress responses.[9]

Clinical and Anthropological Significance

Understanding the relationship between dental markers and pubertal timing may have applications in:

- Dental anthropology
- Forensic odontology
- Pediatric dentistry
- Public health research
- Growth assessment studies

Dental examination may provide a non-invasive method for identifying individuals exposed to developmental stress during childhood.

Limitations in Current Research

Several limitations exist in the current literature:

- Lack of longitudinal studies
- Limited interdisciplinary research
- Difficulty separating genetic and environmental influences
- Population-specific variation in dental traits
- Recall bias in reporting age at menarche

Future studies incorporating genetic, endocrine, nutritional, and dental analyses are required to clarify these associations.

Future Directions

Future research should focus on:

1. Longitudinal cohort studies
2. Standardized assessment of non-metric dental traits
3. Integration of hormonal and anthropometric data
4. Evaluation of developmental asymmetry
5. Comparative studies across populations

Advanced imaging techniques and molecular studies may further improve understanding of developmental stress markers.[10]

CONCLUSION

Non-metric dental features and developmental dental defects provide valuable insight into childhood developmental stress. Early menarche, influenced by genetic and environmental factors, may share common biological pathways with dental developmental disturbances. Although direct evidence linking these phenomena remains limited, current literature supports the possibility of an association mediated through nutritional, hormonal, and psychosocial mechanisms. Further inter-disciplinary research is necessary to establish the role of dental markers in predicting altered pubertal maturation and developmental instability

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FROM BIOMARKERS TO PRECISION ONCOLOGY: THE DUAL ROLE OF ANGIOGENESIS AND MAST CELLS IN OSCC PROGRESSION

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ABSTRACT

Oral squamous cell carcinoma (OSCC) is an aggressive and heterogeneous malignancy increasingly recognized as a complex vascular–immune ecosystem rather than a purely tumor cell-driven disease. This review synthesizes current evidence on the angiogenesis–mast cell axis as a central regulatory network integrating angiogenesis, immune modulation, extracellular matrix remodeling, hypoxia signaling, and therapeutic resistance in OSCC. Mast cells function as dynamic mediators within the tumor microenvironment by releasing pro-angiogenic and immunomodulatory factors including vascular endothelial growth factor, tryptase, chymase, fibroblast growth factors, cytokines, and chemokines. Through bidirectional interactions with endothelial and stromal components, mast cells amplify neovascularization, promote immune evasion, and sustain hypoxia-driven tumor progression. The review further highlights spatial and temporal heterogeneity within the tumor microenvironment, emphasizing the prognostic significance of angiogenic niches identified through multiplex immunohistochemistry, spatial biology, artificial intelligence, and digital pathology platforms. Emerging biomarker strategies integrating vascular, immune, and molecular signatures demonstrate improved diagnostic and prognostic value compared with single-marker approaches. Precision oncology frameworks incorporating multi-omics profiling, liquid biopsy, and computational pathology may enable biologically informed patient stratification and personalized therapeutic selection. Therapeutically, combined targeting of angiogenesis, mast cell signaling, and immune pathways represents a promising strategy to overcome adaptive resistance associated with conventional anti-angiogenic therapies. Despite substantial mechanistic advances, clinical translation remains limited by methodological heterogeneity, lack of standardized biomarker assessment, and insufficient axis-based clinical trials. Overall, the angiogenesis-mast cell axis provides a comprehensive systems-level framework for advancing biomarker development and precision oncology in OSCC. Future validation studies are essential for translating these integrated approaches into practice.

Key-words: Oral squamous cell carcinoma; Tumor microenvironment; Angiogenesis; Mast cells; Vascular–immune crosstalk; Precision oncology; Biomarkers; Hypoxia; Spatial pathology.

INTRODUCTION

Oral squamous cell carcinoma (OSCC) is an aggressive and heterogeneous malignancy with poor survival despite therapeutic advances.[1,2] Although traditional models focused primarily on genetic and epigenetic alterations in malignant epithelial cells,[3,4] current evidence emphasizes the tumor microenvironment (TME) as a major regulator of disease progression through

interactions among stromal, vascular, and immune components.2,5-7

OSCC can therefore be conceptualized as a vascular–immune hybrid tumor in which angiogenesis and immune regulation are closely interconnected. Increased microvessel density and VEGF expression are associated with tumor growth, metastasis, and poor prognosis.[8-11] However, the limited efficacy of anti-angiogenic therapy indicates that angiogenesis alone cannot fully explain tumor progression because adaptive resistance mechanisms within the TME sustain disease evolution.[12,13]

Mast cells have emerged as important mediators linking vascular and immune processes. Through mediators such as tryptase, chymase, cytokines, and VEGF, mast cells contribute to angiogenesis, stromal remodeling, and tumor progression.[14-20] Their functional plasticity enables both tumor-promoting and tumor-suppressive effects depending on the microenvironmental context.[21,22]

Hypoxia-driven signaling further links mast cells and angiogenesis through an "angiogenic-immune coupling," in which mast cell recruitment and vascular remodeling reinforce one another in a self-sustaining feedback loop.[6,23,24] Emerging multi-component and biomarker-based models integrating vascular, immune, and molecular features have demonstrated improved prognostic relevance in head and neck cancers.[19,25-29] Collectively, these findings support an integrated tumor–stroma–immune framework in which the angiogenesis–mast cell axis represents a central mechanism in OSCC pathobiology.

CONCEPTUAL FRAMEWORK: THE ANGIOGENESIS–MAST CELL AXIS

The angiogenesis–mast cell axis describes the bidirectional interaction between mast cells and tumor vasculature within the TME, integrating immune and vascular regulation during OSCC progression.

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How to cite this article : Anuradha O, Jiji G. From Biomarkers to Precision Oncology: The Dual Role of Angiogenesis and Mast Cells in OSCC Progression. Impressions. 2026;16(2):31-39.

Source of support : Nil,

Conflict of Interest : None declared.

Mast cells function as both angiogenic sensors and effector amplifiers. In response to hypoxic and inflammatory signals, they undergo recruitment and activation,[6,23] subsequently releasing VEGF, fibroblast growth factors, tryptase, and chymase that stimulate endothelial proliferation, extracellular matrix degradation, and neovascularization.[19,20] Correlations between mast cell density and microvessel density further support their angiogenic role in OSCC.[16,17,30]

Spatially, mast cells are concentrated in perivascular regions and invasive fronts, where they interact closely with endothelial and stromal cells to form angiogenic niches that promote tumor dissemination.[6,11,24,31] Advances in spatial biology and digital pathology further highlight the prognostic significance of these immune-vascular interactions.[25]

Temporally, mast cell activity evolves during tumor progression. While they may contribute to immune surveillance in early stages,[5,22] hypoxic and

immunosuppressive conditions promote a pro-tumorigenic phenotype associated with angiogenesis, invasion, and extracellular matrix remodeling.[18,32] Increased mast cell density in advanced OSCC supports this transition.[30,31] Overall, the angiogenesis–mast cell axis provides a systems-level framework integrating functional, spatial, and temporal aspects of OSCC progression.

ANGIOGENESIS IN OSCC: BEYOND VEGF

Angiogenesis in OSCC extends beyond VEGF-dependent pathways and involves multiple compensatory mechanisms that contribute to therapeutic resistance.[9,33] VEGF-independent signaling includes fibroblast growth factors, angiopoietins, platelet-derived growth factor, and inflammatory cytokines, many of which are amplified by mast cells and macrophages within the TME.[6,22,34,35] Endothelial cells also contribute through angiocrine signaling that regulates tumor progression.[24,36,37]

Non-canonical mechanisms such as vasculogenic mimicry, in which tumor cells form vessel-like networks independent of endothelial cells, further support tumor perfusion and aggressive behavior.[9,38-40]

Angiogenesis additionally demonstrates marked spatial heterogeneity, with angiogenic "hot" and "cold" regions influencing hypoxia, immune infiltration, and therapeutic response.[6,23,24,41] Multi-omics and spatial profiling studies further support the clinical relevance of this heterogeneity.[25,26]

Traditional reliance on microvessel density alone is therefore insufficient. Functional vascular parameters such as vessel maturity and perfusion provide more accurate assessments of vascular quality and treatment response.[33,41,42] Together, these findings indicate that angiogenesis in OSCC is a complex and adaptive process operating within a broader tumor ecosystem.

MAST CELLS: FUNCTIONAL PLASTICITY IN OSCC

Mast cells are dynamic TME components with context-dependent tumor-promoting and tumor-suppressive functions, making them key regulators of the angiogenesis–immune interface in OSCC.[5,14]

Mast cells are heterogeneous and include MC-T and MC-TC subtypes, which differ in inflammatory, angiogenic, and extracellular matrix remodeling functions.[30,31] Activated mast cells correlate with increased angiogenesis and tumor progression,[17,18] while transcriptomic studies reveal distinct molecular signatures associated with prognosis and immune interactions.[20,21]

Through secretion of VEGF, FGF, tryptase, chymase, IL-10, and TNF-α, mast cells regulate angiogenesis, immune suppression, endothelial proliferation, and extracellular matrix degradation.[14,16,19,22,32,43,44]

Hypoxia promotes mast cell recruitment and activation, driving angiogenesis and tumor survival.[6,23] During tumor progression, mast cells increasingly adopt pro-tumorigenic functions associated with angiogenesis, invasion, stromal remodeling, and immune evasion.[31,32] Increased mast cell density in advanced OSCC further supports this transition.[11,30]

Overall, mast cells represent important biomarkers and emerging therapeutic targets because of their phenotypic diversity and central role in regulating angiogenesis, immunity, and stromal remodeling in OSCC.

MECHANISTIC CROSSTALK: BUILDING THE ANGIOGENESIS-MAST CELL AXIS

The angiogenesis–mast cell axis is sustained through interconnected mechanisms involving protease activity, hypoxia signaling, and immune modulation, collectively promoting tumor progression. Mast cell–derived tryptase and chymase degrade extracellular matrix components, stimulate endothelial proliferation, and enhance angiogenic signaling through PAR-2 activation, matrix metalloproteinase induction, and VEGF/FGF release.[17,19,30,32]

Hypoxia further reinforces this axis by inducing HIF-1α–mediated recruitment and activation of mast cells, which subsequently release VEGF and cytokines that sustain abnormal vasculature and therapeutic resistance.[6,23,24,33] In parallel, mast cells regulate immune–vascular coupling through chemokines such as CCL2 and CXCL8, while promoting immunosuppression via IL-10 and TGF-β, thereby limiting cytotoxic immune responses and facilitating tumor immune evasion.[5,14,22,41-44] Together, these mechanisms establish a self-reinforcing vascular–immune network central to OSCC progression.

SPATIAL AND DIGITAL PATHOLOGY INSIGHTS

Advances in spatial biology and digital pathology have enabled high-resolution characterization of mast cell–angiogenesis interactions within the OSCC tumor microenvironment. Multiplex immuno-histochemistry demonstrates preferential localization of mast cells in perivascular regions and invasive fronts, supporting direct endothelial interaction and formation of angiogenic–immune niches.[2,11,19,31]

Artificial intelligence–based pathology platforms improve quantification of mast cell density, activation status, vascular branching, and microvessel heterogeneity, thereby enhancing prognostic accuracy and histopathological reproducibility.[9,10,20,21,25] Spatial biomarker models integrating vascular, immune, and multi-omics data further identify angiogenic hotspots associated with invasion, hypoxia, and therapeutic resistance, supporting more refined tumor stratification and treatment prediction.[6,24,26,40]

BIOMARKER INTEGRATION: FROM SINGLE MARKERS TO SIGNATURES

The complexity of OSCC has shifted biomarker research from isolated markers toward integrated molecular signatures reflecting the functional state of the tumor microenvironment.[28,29] Composite biomarker panels combining VEGF, CD34, tryptase,

cytokines, COX-2, and hypoxia-related markers improve diagnostic and prognostic precision by simultaneously capturing angiogenic and mast cell activity.[10,19,30]

Liquid biopsy approaches further enable dynamic monitoring of angiogenesis and immune modulation through circulating VEGF, angiopoietins, tryptase, histamine, ctDNA, extracellular vesicles, and proteomic signatures.[14,28,35,45] Integrative predictive models incorporating molecular, cellular, spatial, and vascular parameters improve patient stratification and support personalized therapeutic decision-making.[25,26] Collectively, these approaches position the angiogenesis-mast cell axis as a clinically relevant biomarker framework in OSCC.

PRECISION ONCOLOGY PIPELINE IN OSCC

Precision oncology in OSCC is evolving toward integrated frameworks that align vascular, immune, and stromal biology with therapeutic decision-making.[28,29,46] The angiogenesis-mast cell axis provides a systems-level basis for patient stratification into angiogenic-high/mast cell-high, immune-dominant, and mixed phenotypes, each associated with distinct biological behavior and therapeutic responsiveness.[9,10,16] Multi-omics and spatial profiling studies further support this ecosystem-based classification model.[47]

Therapeutic strategies include anti-angiogenic agents, mast cell–targeted therapies, immune checkpoint inhibition, and dual-target combinations designed to disrupt compensatory vascular–immune feedback loops.[35,48] However, clinical implementation remains limited by inadequate biomarker stratification, insufficient axis-based trials, and lack of standardized spatial and multi-omics integration.[34,49] Overall, biomarker-driven and axis-centered precision oncology pipelines represent a major step toward personalized OSCC management.

THERAPEUTIC TARGETING OF THE ANGIOGENESIS-MAST CELL AXIS

Therapeutic targeting of angiogenesis in OSCC has traditionally focused on VEGF signaling; however, clinical benefit is frequently limited by tumor microenvironment (TME) plasticity and adaptive resistance. Increasing evidence identifies mast cells as critical mediators of this resistance through sustained angiogenic signaling and immune modulation. Mast cells promote VEGF-independent angiogenesis via release of fibroblast growth factor (FGF), angiopoietins, tryptase, and chymase, highlighting the redundancy of vascular regulatory pathways.[9,24] They also contribute to abnormal vascular architecture, impaired drug delivery, hypoxia maintenance, and immunosuppression through cytokines such as IL-10.[6,23,41]

Therapeutic strategies targeting mast cells include tryptase inhibitors, which reduce extracellular matrix degradation and endothelial activation, and c-KIT inhibitors, which suppress mast cell survival and degranulation.[15,30,32] Emerging approaches further aim to disrupt mast cell–derived cytokine signaling, transcriptomic interactions, and hypoxia-mediated recruitment pathways.[20,44]

Given the interdependence of vascular and immune pathways, dual-target strategies combining anti-angiogenic therapy, mast cell inhibition, and immunotherapy may provide superior therapeutic efficacy by improving vascular normalization, enhancing immune infiltration, and disrupting compensatory feedback mechanisms.[5,14,36,41,42] Collectively, these findings support axis-based therapeutic targeting as a promising strategy for overcoming resistance and improving OSCC outcomes.

CHALLENGES IN TRANSLATION

Despite growing mechanistic evidence, clinical translation of the angiogenesis-mast cell axis remains constrained by biological and methodological challenges. Conflicting clinical findings persist regarding the role of mast cells in OSCC, with some studies associating increased mast cell density with tumor progression and poor prognosis, while others suggest protective or context-dependent effects in early-stage disease.[16,32] Angiogenesis itself also demonstrates dual functions, contributing both to tumor progression and vascular normalization.[42]

Additional limitations arise from the lack of standardized methodologies for mast cell assessment. Variability in staining techniques, quantification methods, sampling strategies, and definitions of activation states reduces reproducibility across studies.[30,31] Functional characteristics such as mast cell subtype and activation status may be more informative than absolute cell counts, but consensus protocols remain unavailable.[20]

Spatial heterogeneity further complicates interpretation, as angiogenesis and mast cell infiltration are concentrated within specific niches such as invasive fronts and hypoxic regions.[2,6] Although digital pathology and spatial profiling technologies improve tissue-level resolution, their routine clinical integration remains limited.[10] Addressing these challenges will require standardized

biomarker platforms, large-scale validation studies, and integration of spatial and functional analyses into clinical workflows.

FUTURE DIRECTIONS: TOWARD NEXT-GENERATION PRECISION ONCOLOGY

Future advances in OSCC research and therapy will depend on integrative and technology-driven approaches capable of capturing tumor complexity. Multi-omics integration combining genomics, transcriptomics, proteomics, epigenomics, and spatial profiling enables comprehensive characterization of the angiogenesis-mast cell axis and supports dynamic biomarker development.[28,40,47]

Single-cell sequencing technologies further reveal mast cell heterogeneity and identify functionally distinct cellular subpopulations within the tumor microenvironment.[21,25] In parallel, mast cell reprogramming has emerged as a promising strategy aimed at shifting mast cells toward anti-tumor phenotypes capable of enhancing immune surveillance and promoting vascular normalization.[15]

Artificial intelligence and computational pathology are expected to play increasingly important roles in predictive oncology by integrating multi-dimensional datasets, improving prognostic modeling, and guiding personalized therapeutic selection.[10,25] Collectively, these advances indicate that future precision oncology in OSCC will be increasingly dynamic, systems-based, and computationally integrated.

CONCLUSION

OSCC should be viewed as a complex vascular-immune ecosystem rather than a disease driven solely by malignant epithelial cells. Within this framework, the angiogenesis-mast cell axis functions as a central regulatory network integrating vascular remodeling, immune modulation, extracellular matrix dynamics, and tumor progression.

This systems-level perspective explains the limited efficacy of reductionist therapeutic approaches and emphasizes the importance of tumor microenvironmental context in biomarker development and treatment response. Mast cells emerge as critical amplifiers of angiogenesis, immune suppression, and therapeutic resistance through the release of proteases, cytokines, and angiogenic mediators.

From a translational standpoint, integrating spatial, molecular, vascular, and immune biomarkers with axis-based therapeutic strategies offers substantial potential for improving patient stratification and precision oncology in OSCC. However, successful clinical implementation will require standardized methodologies, robust

validation studies, and biomarker-driven clinical trial designs. Overall, adoption of a systems-based, angiogenesis–mast cell axis–centered framework provides a strong foundation for developing more effective and personalized therapeutic strategies in OSCC.

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AI IN DENTISTRY: ADVANTAGES, HIDDEN DISADVANTAGES, AND FUTURE DEVELOPMENTS

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ABSTRACT

Dentistry is an art that requires a lot of work, precision and good clinical judgment. Detecting tooth decay on X-rays and restoring a tooth's natural shape are tasks that demand great skill and experience. Artificial intelligence(AI) can help dentists by reducing their workload, minimizing mistakes and improving accuracy. This allows dentists to focus more on the side of care and providing better patient care. Recent studies show that artificial intelligence has a lot of potential but some limitations. The current uses of AI in dentistry have been introduced and summarized. Even though dentistry is a field that benefits from innovations to treat oral diseases dentists are slow to adopt new technology.[1] In the future a comprehensive care system based on AI is expected to provide high quality patient care and drive innovative research and development. This will enable decision support tools.[2] This article looks at the applications, benefits, drawbacks and future developments of intelligence in dentistry.

Keywords: Artificial intelligence, Dentistry, Advantages, Hidden disadvantages, Future developments.

INTRODUCTION

Artificial Intelligence is the way machines can think like people. AI can be put into groups, including machine learning, natural language processing, robotics, computer vision and expert systems. AI is changing industries, including healthcare. AI is really helping the dental field by making things more efficient and reducing the amount of work that needs to be done. Artificial Intelligence is very good at finding patterns in data so it is being used a lot in clinical trials to help make decisions about diagnosis and treatment. AI is also being used to predict what will happen in the future. In dentistry AI can play a role. For a time public health in dentistry has relied on people looking at things manually using old fashioned X ray machines and screening people in groups, which can be a lot of work and prone to mistakes. These old methods can cause delays in diagnosis and waste resources. This means that some communities may not get the level of care as others.

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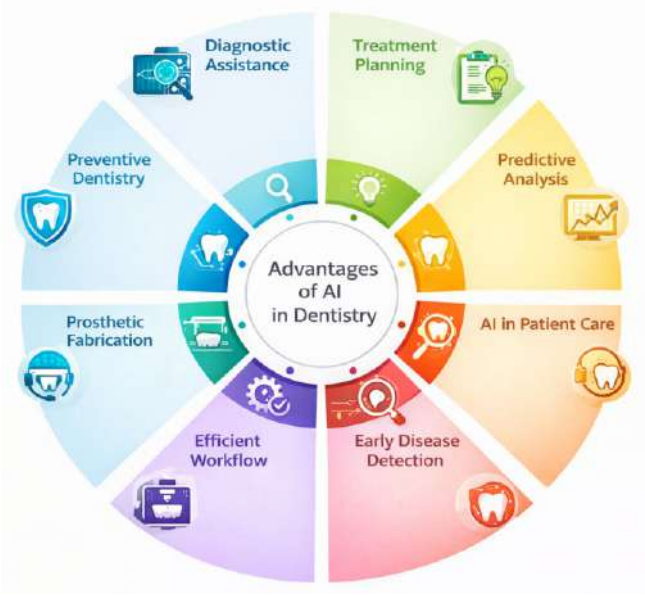
How to cite this article : Unzela S, Rajput G. AI in Dentistry: Advantages, Hidden Disadvantages, and Future Developments. Impressions. 2026;16(2): 40-45.

Source of support : Nil,

Conflict of Interest : None declared.

With new technology AI is starting to change the way dentistry works. AI can do simple tasks in dental clinics more accurately using fewer people and making fewer mistakes than humans. With digitalization AI is being used in many areas from scheduling appointments to helping with diagnosis and treatment planning and even designing prostheses and educating people. Using AI in dentistry reduces mistakes made by people.[4] Saves time and money. A lot of information can be used to create an AI that can help with quick diagnosis and treatment planning. Machines can also work for hours without getting tired whereas people need to take breaks before they can do important tasks. AI is really good at doing things over with minimum mistakes and it can work long hours without stopping. This makes AI very useful, in dentistry.[5]

ADVANTAGES OF AI IN DENTISTRY



1.Diagnostics Assistance: AI powered tools can look at dental pictures, including x-rays and photos taken inside the mouth to find problems and help doctors catch diseases early. This makes diagnosis more accurate and faster. Dental images are very important for doctors to see what is going on in the mouth. AI powered tools can analyse these images to identify abnormalities.

2. Treatment planning: AI can help doctors plan treatments like fixing teeth that're not straight and putting in implants. By looking at information AI can give doctors ideas for treatments that are just right for each patient, which leads to better results. AI is very useful in treatment planning for procedures such as orthodontics and implant placement.

3. Predictive analytics: AI can tell doctors about risks for each patient like how likely they are to get cavities, gum disease or mouth cancer. This helps doctors take steps to prevent these problems. AI algorithms can predict specific risks, such as the likelihood of developing dental caries.[6]

4. AI in patient care: AI can make the experience of going to the dentist better for patients. Virtual assistants that use AI can schedule appointments, teach patients about their teeth and answer questions. AI can also look at what patients say about their care. Help doctors find ways to improve. AI has the potential to improve the patient experience in dentistry including AI in patient care.

5. Early disease detection: AI is being used to look at pictures like x-rays and scans to find early signs of mouth diseases, such as cavities, gum disease and mouth cancer. By using machine learning and finding patterns AI systems can help doctors see problems that they might not see otherwise which means they can start treating the problem and get better results. AI algorithms are being developed to analyze images, such as X-rays to detect early signs of oral diseases, including dental caries and oral cancer. AI is very useful, in disease detection.[7]

6. Efficient Workflow: Artificial Intelligence can make the work easier in dental offices by taking care of things like scheduling appointments, sending bills and talking to patients. This means the people who work at the office can spend more time taking care of patients, which makes the patients happy.

7. Prosthetic Fabrication: Artificial Intelligence is used with machines that can make exact copies of things like 3D printing and CAD/CAM. These machines can make dental prosthetics like crowns, bridges and dentures quickly and precisely.

8. Preventive Dentistry: Artificial Intelligence can look at information and predict which patients might have certain problems with their teeth. The dentist can then help these patients on so they do not have to get expensive and painful treatments later on.[8]

HIDDEN DISADVANTAGES OF ARTIFICIAL INTELLIGENCE IN DENTISTRY

Artificial Intelligence has become a part of areas of our lives including healthcare and dentistry is no exception. The use of Artificial Intelligence in dentistry has promised good things but it also raises a lot of questions and concerns. Here are some hidden disadvantages of AI that need to be thought about.

1-Data privacy concern: One of the worries about using AI in dentistry is the issue of patient consent. Artificial Intelligence systems need a lot of data including medical records, images and genetic information to make predictions and suggestions. The large amount of data that AI systems collect and use raises concerns about keeping data safe, storing it properly and stopping people from accessing it without permission.

2-Ethical and Legal Considerations: Using AI in healthcare also brings up ethical and legal issues. One of the problems is that AI systems can be biased, which means they can treat people unfairly based on the data they were trained with. This can lead to treatment results for different groups of people. To fix these biases the design of Artificial Intelligence systems needs to be clear and monitored all the time to make sure patients are treated fairly and equally. Also when Artificial Intelligence systems are used to care for patients there are problems about who is responsible if something goes wrong like a wrong diagnosis or treatment mistake. This makes the legal situation complicated and requires rules and guidelines. Artificial Intelligence in dentistry needs to be used in a way. Additionally, legal challenges surrounding liability and accountability arise when AI systems are involved in patient care, particularly in misdiagnosis or treatment errors. Determining responsibility whether with the healthcare provider, the AI developer, or the technology itself complicates the legal landscape and necessitates clear regulations and guidelines (McLennan et al., 2022; Naik et al., 2022).[9]

3-Depersonalization: While Artificial Intelligence can make administrative tasks easier there is a concern that relying much on technology may make the patient experience less personal. Some patients may prefer personalised treatment when it comes to their dental care.[8]

4-Diagnostic errors:

(a) False Positive: This is when the Artificial Intelligence system says someone has an oral disease when they really do not. For example it might say someone has a cyst when they really just have a mental foramen. It might say someone has a cavity when they really just have a groove shadow. This can happen between 3-12% of the time for cavities and high as 35% of the time for other problems that show up on CBCT scans according to the Diagnocat Study in 2025. These mistakes can lead to treatments that make patients anxious and cost more money.

(b) False Negative: This is when the Artificial Intelligence system fails to detect a disease that is really there. For example it might miss cavities or small problems. This can happen as much as 49% of

the time for early cavities according to Szabó and colleagues in 2024 and 8.3% of the time for serious oral lesions according to Vaira and colleagues in 2025. These mistakes can let the disease get worse, delay treatment and will be problematic for the patient.

(c) Localisation errors: This is when the Artificial Intelligence system finds a problem. Says it is in the wrong tooth or place. Studies have found that this can happen 4.4% of the time for radiographs according to Ayyıldız and colleagues in 2024 and as much as 13 mm off for certain landmarks according to BMC Oral Health in 2025. These mistakes can lead to treating the tooth mistakes in orthodontic calculations and errors in surgical planning, for dental care and AI.

5-Lack of Transparency in Diagnostic Reasoning : Lack of transparency in healthcare systems is a foremost challenge that compromises accountability and diminishes public confidence. Lack of transparency in their decision making processes has brought about critical concern on issues of trust, accountability of ethics and regulatory requirements in healthcare environments. The opaqueness of these AI systems is a critical concern in medical contexts, where patient health, ethical accountability and regulatory compliance are at stake. Healthcare practitioners and patients require transparency in the logic behind clinical decisions to ensure informed consent, diagnostics, and automated systems are accurate and trustworthy.[10]

6-Over Reliance Leading to Eroded Clinical Skills : Artificial intelligence or any form of machinery has been created solely by human intelligence and skills. Over dependence on AI can assist devices to hinder the clinical skills of a dental operator gradually. Without clinical judgment and skilled hands, dentistry is nothing. However, AI can only be used as an additional tool to maintain the human factor and reinforce the authority of dentists in treatment protocols and judgements.[11] The issues of over reliance on AI, deskilling of medical professionals, and meaningful oversight of AI decisions are critical.[9] Also, human functions such as team work and leadership are not likely to be achieved as machines are not able to make connections with humans.

7-High cost: The high cost of AI in dentistry results primarily from costly hardware components, recurring software subscription costs, and costs of training staff and storing cloud data. It is expensive for smaller or solo dental practices to adopt advanced AI functionalities such as real time radiographic analysis, implant planning, and automated patient communication, although larger group practices may negotiate for lower rates or use their increased diagnostic accuracy, efficiency gains, and case acceptance to offset costs. While limited free trials and pay per analysis options exist, widespread adoption remains limited until competition becomes more widespread and prices fall.

8-Effects on healthcare professionals : The integration of AI into healthcare will disrupt established workflows. It means that the professionals in the field have to adjust to working differently. There are worries that AI will negatively affect the health and job satisfaction of healthcare professionals because their role in decision making will change. With the improvement of technology, some healthcare jobs will be automated and no longer available. For example, medical coding and simple diagnoses will eventually be done by AI. Also, the employment of AI in healthcare implies that healthcare workers will need additional skills to compete in the market.

9-Patient dissatisfaction : Feelings of dissatisfaction as a result of being examined and treated in a digital environment may also occur in

patients. This may be due to loss of human connection, lack of empathy, lowered trust in automated decision making, and communication barriers.

FUTURE DEVELOPMENTS

Nevertheless, the future of AI in dentistry does look bright. Ongoing research and development are underway to have AI algorithms enhanced and have the capacity to be used more widely in dentistry. For example, AI has also been studied on how it can be used in orthodontics to accurately predict treatment results and moving teeth. In addition, the use of AI empowered robotics in dental procedures is to be researched that can ensure increased accuracy and precision. These recent developments are certainly revolutionary and can transform the future treatment outcome and the dentistry field itself. In the near future, dental clinics would be using a comprehensive AI system in practice. This not only helps to manage patient's medical histories and data but also enables a clearer understanding and detection of various oral diseases leading to improved medical care. AI eradicates all clinical errors by giving inclusively feedback on patient's allergic history, diseases and drugs etc. and hence ultimately improve the treatment outcomes and patient treatment. The entire dental work flow would be fully mechanized via AI and hence improved treatment results. AI is progressing at a fast pace, making it possible for robots to do tasks that can normally only be achieved by humans. Dentistry is a recent addition to the list of industries using AI, and this has led to incredible successes in processing clinical dental data.

Developments in AI show potential advantages to health care including enhanced decision-making, the reduction of unnecessary treatments, improved life quality, reduction of complications after operation and so on and machine learning wherein prediction of outcome is attempted from a list of data without interference of human beings. In conclusion, Automated Intelligence is not a myth and it is the future of dentistry. Its use in every part is increasing exponentially. Though it can never take the place of the dentist who not only diagnoses but also correlates the various clinical findings and provides a treatment plan to the patient. However a good knowledge about various techniques and ideas of the AI can surely prove to be an advantage in the upcoming time. Maybe we can soon see AI to be fully used in orthodontics, endodontics and restorative dentistry (reconstructive surgeries). The only limit in the use of AI right now is due to the fact that the data used is less and faulty. It is the dentist's and clinician's job to focus on gathering and entering the correct data in their database which will fully use the AI in many aspects of dentistry in the imminent future.[12] In the past years AI has been felt as both an opportunity and a threat. One idea was to offer a comprehensive curriculum of the basics of AI for undergraduates and incorporate it into practice and research. Furthermore, they supported integration of AI principles into education, research, and practical training emphasizing on practical applications. Other suggestions were integration of AI training within faculty capacity building programs, conducting computer-presented interactive workshops and debates on the basis of AI nevertheless, we have to be cautious of the data protection issues that may arise and overdependence on AI furnished suggestions, considering the immense opportunities of generative AI in dentistry.[13]

CONCLUSION

As technology has developed, artificial intelligence in the healthcare sector, dentistry included has seen a great use. Whether it is finding abnormalities and making predictions based on analysis of radiographic images, providing a

tailored treatment plan, assisting clinical decision making or developing the computer skills of students, there are numerous benefits yet there are two sides of each coin so the hidden disadvantages seem unforgiving. Some of these are data privacy issues, their effect on practice in terms of ethics, medical error risk, lack of transparency with diagnoses made by machines and the most painful of all, the possible loss of potentially valuable clinical skills. However if the future developments of AI can overcome these hitches there could be an almost magical outcome for humankind by raising the standard of patient care without compromising the independence of the dentist.

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JOURNAL OF INDIAN DENTAL ASSOCIATION ATTINGAL BRANCH

Volume - 16., Issue - 2 | MAY-JULY 2026