ISSN 0973-2063 (online) 0973-8894 (print)

Bioinformation 22(10): 6452-6457 (2026)

©Biomedical Informatics (2026)

BIOINFORMATION
Discovery at the interface of physical and biological sciences

BIOMEDICAL INFORMATICS

www.bioinformation.net

Volume 22(10)

Research Article

Received October 1, 2026; Revised October 31, 2026; Accepted October 31, 2026, Published October 31, 2026

DOI: 10.6026/973206300226452

SJIF 2026 (Scientific Journal Impact Factor for 2026) = 8.478
2022 Impact Factor (2023 Clarivate Inc. release) is 1.9

Declaration on Publication Ethics:
The author's state that they adhere with COPE guidelines on publishing ethics as described elsewhere at https://publicationethics.org/. The authors also undertake that they are not associated with any other third party (governmental or non-governmental agencies) linking with any form of unethical issues connecting to this publication. The authors also declare that they are not withholding any information that is misleading to the publisher in regard to this article.

Declaration on official E-mail:
The corresponding author declares that lifetime official e-mail from their institution is not available for all authors

License statement:
This is an Open Access article which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly credited. This is distributed under the terms of the Creative Commons Attribution License

Comments from readers:
Articles published in BIOINFORMATION are open for relevant post publication comments and criticisms, which will be published immediately linking to the original article without open access charges. Comments should be concise, coherent and critical in less than 1000 words.

Disclaimer:
Bioinformation provides a platform for scholarly communication of data and information to create knowledge in the Biological/ Biomedical domain after adequate peer/editorial reviews and editing entertaining revisions where required. The views and opinions expressed are those of the author(s) and do not reflect the views or opinions of Bioinformation and (or) its publisher Biomedical Informatics. Biomedical Informatics remains neutral and allows authors to specify their address and affiliation details including territory where required.

Edited by P Kangueane
Citation: Shah *et al.* Bioinformation 22(10): 6452-6457 (2026)

Knowledge and perception of Periodontology postgraduate students with dental interns regarding 3D printing for periodontal regeneration

Sakshi Romil Shah, Jasuma Rai* & Soniya Sawakare

Department of Periodontology, KM Shah Dental College and Hospital, Sumandeep Vidyapeeth Deemed to be University, Vadodara, Gujarat, India; *Corresponding author

Affiliation URL:
https://dental.sumandeepvidyapeethdu.edu.in/

Author contact:
Sakshi Romil Shah - E-mail: sakshiromilshah@gmail.com; Phone: +91 7522971682
Jasuma Rai - E-mail: drjasumaj@gmail.com; Phone: +91 9974005760

ISSN 0973-2063 (online) 0973-8894 (print)
Bioinformation 22(10): 6452-6457 (2026)
©Biomedical Informatics (2026)

Soniya Sawakare - E-mail: soniya132000@gmail.com; Phone: +91 9920369625

Abstract:
Additive manufacturing has emerged as an assuring technology by enabling the creation of surgical guides and patient - specific scaffolds with accurate control over shape, porosity and internal architecture. Therefore, it is of interest to assess and compare the knowledge and perception of 3D printing amongst Periodontology postgraduate students and dental interns of India. A validated, self – administered questionnaire was conducted among 250 Periodontology postgraduate students and dental interns of India which consisted of 15 questions. Knowledge of 3D printing for periodontal regeneration about biomaterials used was 45%, advantages 51% and future directions 50% and postgraduate student's showed better understanding towards 3D printing as compared to dental interns.

Keywords: Additive manufacturing, periodontal regeneration, bone scaffolds

Background:
Over the past few decades, digitalisation and three-dimensional (3D) printing have completely reformed dentistry **[1].** Amid the numerous applications of digitalisation and technology in dentistry are investigations, student guidance and coaching and laboratory techniques **[2].** 3D printing, sometimes referred to as additive manufacturing (AM) or rapid prototyping, is a process that uses advanced imaging and scanning or Computer - Aided Design / Computer - Aided Manufacturing (CAD / CAM) technology to add layers of material towards the production of an object or structure **[1-3]**. The subject of periodontal regeneration is continuously growing, with new advancements and the ability to create patient-specific scaffolds, membranes and surgical guides with exact control over shape, porosity and internal architecture. 3D printing has become an assuring technology with addition to bone grafts, membranes and guided bone regeneration (GBR) **[4].** 3D printing has aided the fabrication of personalized scaffolds and membranes with controlled architecture and tailored mechanical and biological properties **[5].** The following areas of periodontal regeneration where rapid prototyping is most seldom used are: Biomimetic scaffolds that imitate the intricate anatomy of periodontal deficiencies that can be created by using 3D printing. The alveolar bone, cementum and periodontal ligament can all regenerate with the help of these scaffolds. Cell migration, vascularization and nutrient transport are all enhanced by the regulated pore size and interconnectivity **[6].** Additive manufacturing can be used to generate patient-specific resorbable and non-resorbable membranes. These membranes retain room for selective cell repopulation, fit over intrabony and furcation defects precisely and increase wound stability and clinical results **[7].** Mesenchymal stem cells and growth factors can be incorporated into 3D-printed scaffolds. This helps periodontal regeneration by allowing for the regulated release and improved differentiation of osteogenic and fibroblastic cells **[8].** In periodontally deficient sites, 3D-printed surgical guides based on CBCT data can boost precision in flap design, graft insertion and implant alignment. Pre-surgical planning and education are aided by physical models of periodontal abnormalities **[9].** With separate compartments for bone, periodontal ligament and cementum regeneration, advanced bioprinting makes it possible to create multi-layered scaffolds that resemble the natural periodontium **[10].** The benefits and drawbacks of 3D printing have been highlighted in surveys that evaluated the knowledge and practices of dentists in Maharashtra **[11].** A study looked at how social media influences dental professionals use of 3D printing **[12].** Since data **[13]** is available on knowledge, attitude and practise of dentists and dental technicians on 3D printing. Therefore, it is of interest to evaluate the knowledge and perception of Periodontology postgraduate students and dental interns on 3D printing for periodontal regeneration.

Materials and Methods:
This cross–sectional questionnaire survey received approval from Institutional Ethical Committee (Approval No. SVIEC/ON/Dent/BNPG25/March/26/97; March 5, 2026). Electronic informed consent was obtained from all the participants before survey completion. The survey was proposed, supervised and testified in accordance with CHERRIES established criteria **[14, 15].** The questionnaire content validity was evaluated by eight experienced periodontists holding more than 5 years of experience in this field. All questions achieved excellent content validity (Item-Level Content Validity Index (I-CVI) = 1.00; Scale-Level Content Validity Index (S-CVI) = 1.00). No reliability testing was performed for the participants. The final questionnaire comprised 15 questions across three sections: demographic data, knowledge and perception regarding 3D printing for periodontal regeneration. The survey included Periodontology postgraduate students registered with the Dental Council of India and dental interns from Indian dental institutions. Individuals unwilling to participate, undergraduate dental students, dental technicians, teaching and non-teaching faculty and those without internet / social media access were excluded. The sample size was calculated using the formula $n = ((Z_ (1 - a /2))^2 (pq))/d^2$ with an assumed prevalence of 80%, 95% confidence level and 5% absolute precision yielding a required sample of 246 participants. 95% Wilson confidence interval were calculated for the most frequent response to each questionnaire item and effect size were reported using Cramer's V. Snowball sampling was used for maximum participation. The survey required a Google sign-in to restrict responses to one per participant, email addresses were used solely for validation and were excluded from the final dataset. No missing responses were reported. Responses from the survey were transferred to a Microsoft Excel

(version 16.0; Microsoft, Redmond, WA, USA) spreadsheet for data entry and preliminary analysis. The Statistical Package for Social Science (SPSS) version 21 for Windows (SPSS Inc., Chicago, IL) was used for statistical analysis. The mean and standard deviation were used to convey descriptive quantitative data respectively. Frequencies and percentages were used to express descriptive qualitative data. The Chi-square test was used to evaluate associations between participant groups and questionnaire responses.

Results:

After the questionnaire was circulated an overall of 250 responses (101.6%) was successfully achieved from the target statistical power sample size. Out of which 128 came from Periodontology postgraduate students and 122 were dental interns **(Table 1).** Among them, 127 respondents were male and 123 respondents were female with most respondents belonging to the age group of 24-27 years. Regarding the knowledge of 3D printing, about 46.9% postgraduate students were familiar about 3D printing in dentistry with 45.9% dental interns being unfamiliar about 3D printing ($p < 0.001$) **(Table 2)**, of which we discovered that 3D printing is most commonly used in Periodontology and Implantology (58.4%) followed by Oral Medicine and Radiology (42.4%) **(Table 4)**. 50.7% postgraduate students believe that 3D printing is most commonly used for bone scaffolds followed by 47.6% in guided tissue regeneration (**Table 3).** Coming to the knowledge of periodontal regeneration, 51% postgraduate students believe the primary advantage of using 3D printing is to incorporate bioactive factors ($p = 0.664$) (**Figure 1a**). 41% postgraduate students believe that using 3D printing is time saving and it reduces scarring (45%). Biodegradability is the key factor to consider when designing a 3D printed scaffold for periodontal regeneration as answered by 46% postgraduate students (**Figure 1b**). 34% postgraduate students and 20% dental interns were acquainted of the current limitations of 3D printing for periodontal regeneration**.** Regarding the future directions and potential advancement in 3D printing for periodontal regeneration, 50% postgraduate students have answered printing technologies ($p = 0.222$) (**Figure 1c**). For the perception of periodontal regeneration, 34% postgraduate students think that 3D printing can improve the aesthetic outcomes of periodontal regeneration and will change the way dental practices operate in the future ($p = 0.061$) **(Figure 2).**

Table 1: Demographic data of the respondents

Characteristic	Group	Number (n)	Percentage (%)
Gender	Male	127	50.80%
	Female	123	49.20%
Academic Level	Periodontology Postgraduate students	128	51.20%
	Dental Interns	122	48.80%
Total Participants		250	100

Table 2: Knowledge regarding 3D printing in dentistry and periodontal regeneration

Response	PG Students n (%)	Intern's n (%)	Total n (%)	P – Value
Very familiar	60 (46.9)	22 (18.0)	82 (32.8)	
Somewhat familiar	46 (35.9)	44 (36.0)	90 (36.0)	**<0.001***
Not familiar	22 (17.1)	56 (45.9)	78 (31.2)	

Note - *** Highly Significant, * Significant*

Table 3: Areas of Periodontology where 3D printing is mostly used

Response	PG Students n (%)	Interns' n (%)	Total n (%)	P – Value
Customized membranes	41 (32.0)	33 (27.0)	74 (29.6)	
Surgical guides	52 (40.6)	33 (27.0)	85 (34)	**0.041***
Guided tissue regeneration	61 (47.6)	64 (52.4)	125 (50)	
Bone scaffolds	65 (50.7)	56 (45.9)	121 (48.4)	

Note - *** Highly Significant, * Significant*

Table 4: Dental specialties in which 3D printing is commonly used

Response	PG Students n (%)	Interns n (%)	Total n (%)	P – Value
Orthodontics and Dentofacial Orthopedics	41 (32.0)	36 (29.5)	77 (30.8)	
Oral and Maxillofacial Surgery	49 (38.2)	36 (29.5)	85 (34)	**0.076**
Oral Medicine and Radiology	60 (46.8)	46 (37.7)	106 (42.4)	
Periodontology and Implantology	78 (60.9)	68 (55.7)	146 (58.4)	

Note - *** Highly Significant, * Significant*

Discussion:

Prosthodontics, Orthodontics, Restorative Dentistry, Oral Implantology and Endodontics are some of the branches that use 3D printing. Potential periodontal uses of 3D printing, such as scaffold construction, alveolar ridge preservation, bone augmentation, guided implant insertion and instructional models, were documented by Gul *et al.* **[16]**. Despite its progress, there is a dearth of information regarding Periodontology postgraduate students and dental interns' perceptions and knowledge of 3D printing. The primary forte of this survey is the investigation on 3D printing in dentistry among postgraduate students in Periodontology and dental interns, both of which dynamically participate in the clinical and laboratory fabrication of the desired products.

ISSN 0973-2063 (online) 0973-8894 (print)
Bioinformation 22(10): 6452-6457 (2026)
©Biomedical Informatics (2026)

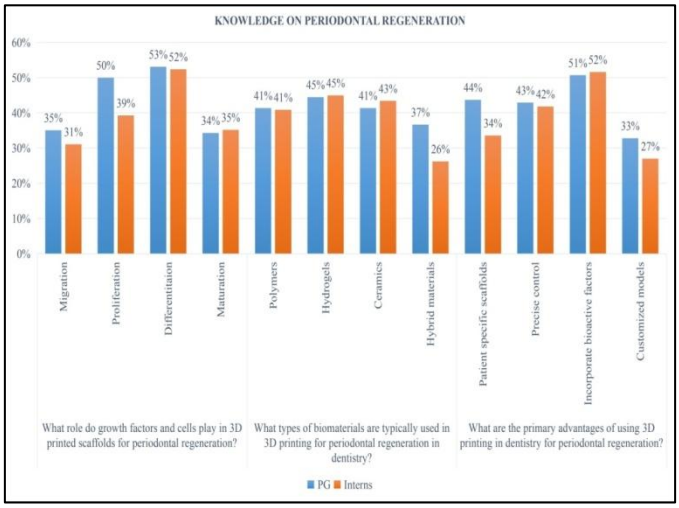


Figure 1a: Knowledge on periodontal regeneration

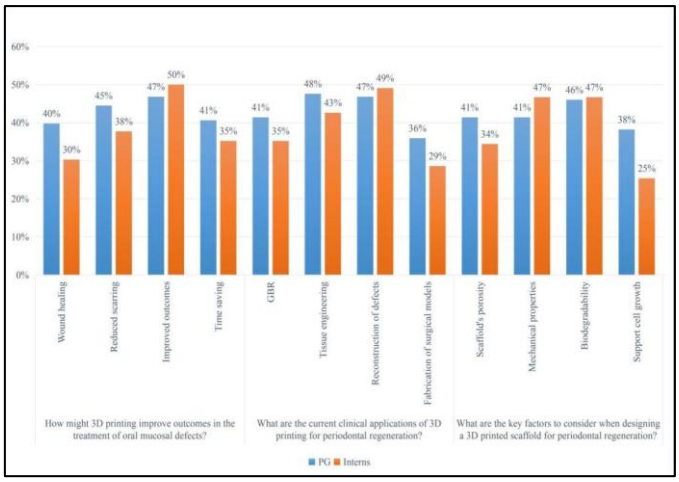


Figure 1b: Clinical uses of 3D printing in periodontal regeneration

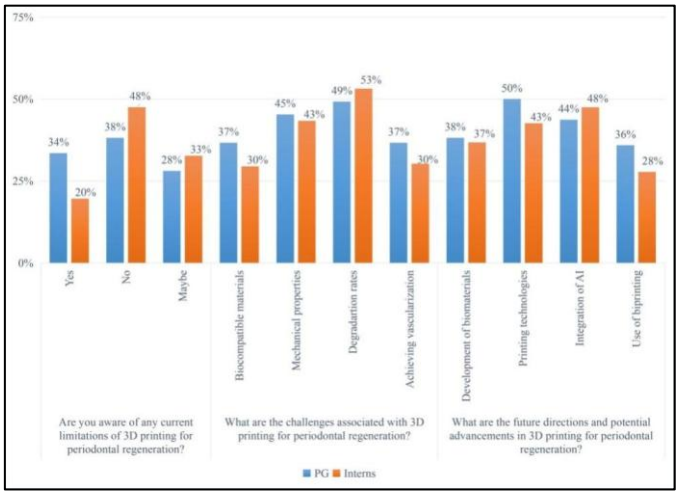


Figure 1c: Limitations and future directions of 3D printing in periodontal regeneration

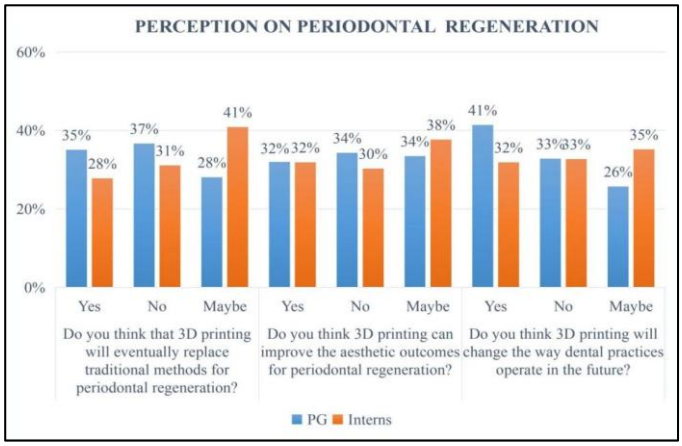


Figure 2: Perception of periodontal regeneration

According to Gattani *et al.* **[17]**, 3D printing allows for the customisation of periodontal regenerative therapies and may enhance surgical planning by utilizing various additive manufacturing processes. A survey done by Jawahar *et al.* **[18]** stated that 73% dental practitioners contemplate that 3D printing is used in India and 25% think that it is not used in India. Acharya *et al.* **[13]** conducted a cross – sectional questionnaire study where he discovered that 98.9% practitioners were familiar about the usage of digital technology in dentistry with 17.7% dental technicians being unfamiliar about 3D printing and according to our survey, 46.7% postgraduate students are very familiar about 3D printing and 45.9% dental interns are unfamiliar about 3D printing ($p < 0.001$). Hegedus *et al.* **[12]** stated that 81.6% practitioners think of using 3D printing to create intricately designed prostheses and, in our survey, almost 50.7% postgraduate students recommended that 3D printing can be useful for bone scaffolds followed by 47.6% in guided tissue regeneration ($p = 0.041$). 3D printing technologies modify facial implants for every patient with the use of imaging techniques like computed tomography (CT) and magnetic resonance imaging (MRI) **[19].** A variety of metal products, including AM titanium dental implants, custom titanium mesh for bone grafting procedures, crowns and bridges and prostheses that can produce dense end products, have been produced using metal alloys in 3D printing, **[20]** and according to our survey, 41% of both dental interns and postgraduate students believe that polymers (example – Poly lactic- co -glycolic acid (PLGA)and Polycaprolactone (PCL)) are compatible with 3D printing ($p = 0.206$). According to Vijay *et al.* **[21]**, 3D printing has the ability to stimulate the regeneration of missing periodontal tissues and create customized constructions made of biocompatible materials. Before regenerative biomaterials are used in clinical settings, their biological performance should be assessed using outcomes including mineralisation, cellular differentiation, immunomodulatory effects and angiogenesis **[22]**. A questionnaire study by Alamri *et al.* **[23]** found that 94.4% dental students recognized the advantages of 3D models for the placement of an implant and in our survey, 51% postgraduate students anticipate that 3D printing can be used to incorporate

bioactive factors (p = 0.664). The controlled positioning of cells, biomaterials and growth factors within scaffolds intended to promote the regeneration of gingival tissues, alveolar bone and periodontal ligament is made possible by recent advancements in 3D bioprinting **[24]**. 76.7% dental interns think that when a product is 3D printed, there is slight waste of raw materials. A 40% reduction in material waste can improve the sustainability of manufacturing **[25].** Up to 95–98% of the powder material used in Selective Laser Melting (SLM) and Selective Laser Sintering (SLS) can be recycled during the printing process **[26].** Coming to the amount of time spent on patients care, 76% practitioners have confidence that 3D printing saves time. One-day dentistry can benefit from 3D printing, but in order to ensure a smooth and accurate workflow, significant execution is necessary before taking a final decision. The postgraduate students had a better understanding and knowledge regarding 3D printing for periodontal regeneration as compared to dental interns. Due to a drought of services, support, training and knowledge, dental practitioners and dental technicians might experience a difficult time in determining which brand to procure or complications in the creation of products **[12]** and according to our survey, 34% postgraduate students and 20% dental interns find these as the limits of 3D printing for periodontal regeneration (p = 0.045). Although there are still issues with clinical translation, recent developments in 3D printing and CAD/CAM technologies have increased the possibility of patient-specific periodontal scaffolds **[27]**. According to postgraduate students and dental interns, the difficulties with 3D printing for periodontal regeneration are degradation rates (49%) and mechanical properties (45%) (p = 0337). The regenerative capacity of 3D-printed scaffolds depends partly on membrane design, permeability and pore properties, which influence cellular repopulation and tissue regeneration **[28]**. Recent advances in 3D - printed periodontal scaffolds have focused on improving material properties, scaffold architecture, bioactivity and personalized regenerative approaches; although challenges related to degradation, mechanical properties and clinical translation still remain **[29].** By assisting in the repair of intricate periodontal tissues, the combination of bioactive delivery technologies, tissue engineering techniques and 3D-printed scaffolds presents new possibilities for periodontal regeneration **[30].** The significance of incorporating digital technology into dental education is shown by evaluating dental students' knowledge, practical experience and educational preferences about 3D printing **[31]**. Consequently, workshops, social media and webinars should be used for efficient training, experience and information sharing. 3D printing must be integrated in dentistry, postgraduate courses and undergraduate courses. The present study enhances current knowledge by delivering specialty - specific evidence on the knowledge and perception of Periodontology postgraduate students and dental interns regarding 3D printing in periodontal regeneration. It relates an educational gap between the two groups and emphasizes the need for structured education, hands - on training and curriculum integration to empower the suitable clinical application of 3D printing in Periodontology.

Conclusion:

By improving treatment precision, customization and regenerative results, 3D printing has completely transformed Periodontology by bridging the gap between biological regeneration and digital technology. It is anticipated that 3D printing will become a crucial component of standard periodontal care and education as research advances and technology becomes more accessible and inexpensive for our budding dentists. Additive manufacturing will be crucial to enhancing patient care, clinical success and long-term periodontal health in the future of Periodontology, which is focused on individualized and digitally driven treatment options.

Declaration of competing interests:

The authors reported no potential conflicts of interest.

Support and funding:

Authors received no support and funding for this work.

References:

[1] Pillai S *et al. Polymers (Basel).* 2021 **13**:157 [PMID: 33406617]
[2] Bhambhani R *et al. J Indian Prosthodont Soc.* 2013 **13**:165 [PMID: 24431730]
[3] Gupta C *et al. Indian J Oral Health Res*. 2018 **4**:35 [DOI:10.4103/ijohr.ijohr_19_18]
[4] Rasperini G *et al. J Dent Res*. 2015 **94**:153S [PMID: 26124215]
[5] Fischer NG *et al. Dental Materials*. 2025 **41**:283 [PMID: 39794220]
[6] Park CH *et al. Tissue Eng Part C Methods.* 2014 **20**:533 [PMID: 24188695]
[7] Bottino MC *et al. Dent Mater*. 2012 **28**:703 [PMID: 22592164]
[8] Obregon F *et al. J Dent Res*. 2015 **94**:143S [PMID: 26124216]
[9] Miron RJ & Zhang Y. *Acta Biomater*. 2018 **75**:35 [PMID: 29772345]
[10] Vaquette C *et al. Adv Healthc Mater*. 2018 **7**:e1800457 [PMID: 30146758]
[11] Dhokar A *et al. J Indian Acad Oral Med Radiol.* 2020 **31**:127 [DOI:10.4103/jiaomr.jiaomr_49_20]
[12] Hegedus T *et al. Int J Environ Res Public Health.* 2022 **19**:1921 [PMID: 35206116]
[13] Acharya A *et al. J Oral Biol Craniofac Res*. 2023 **13**:476 [PMID: 37250816]
[14] Burns KE *et al. Cmaj*. 2008 **179**:245 [PMID: 18663204]
[15] Eysenbach G *et al. Journal of medical Internet research*. 2004 **6**:e34 [PMID: 15471760]
[16] Gul M *et al. J Indian Soc Periodontol.* 2019 **23**:504 [PMID: 31849394]
[17] https://www.worldwidejournals.com/international-journal-of-scientific-research-(IJSR)/fileview/3d-printingperiodontal-perspective-_November_2020_0166141641_0301112.pdf
[18] https://www.jrmds.in/articles/knowledge-on-applications-of-3d-printing-in-dentistry-among-dental-practitionersa-kap-survey.pdf

[19] Memon AR *et al. Expert review of medical devices.* 2020 **17**:345 [PMID: 32105159]
[20] Suzuki Y *et al. Dental Materials Journal*. 2021 **40**:265 [PMID: 33361665]
[21] Vijay DS *et al. Univ J Dent Sci.* 2025 **11**:1 [DOI: 10.21276/ujds.2025.11.1.19]
[22] Daghrery A *et al. Dent Mater*. 2025 **41**:306 [PMID: 39824690]
[23] Alamri H *et al. Frontiers in Dental Medicine*. 2024 **5**:1466393 [PMID: 39917671]
[24] Mhaske M *et al. Int J Res Rep Dent.* 2026 **9**:158 [DOI: 10.9734/ijrrd/2026/v9i1287]
[25] Alharbi N *et al. International Journal of Prosthodontics*. 2017 **30:**474 [PMID: 28750105]
[26] Loges K & Tiberius V. *Materials.* 2022 **15**:431 [PMID: 35057149]
[27] https://www.sciencedirect.com/science/article/pii/S2950643326000188
[28] Mutthineni RB.*IP Int J Periodontol Implantol.* 2025 **10**:157 [DOI: 10.18231/j.ijpi.62858.1762166992]
[29] Chen H *et al. Iscience*. 2025 **28**:112532 [PMID: 40487440]
[30] Daghrery A *et al. Current Oral Health Reports.* 2026 **13**:1 [PMID: 41608086]
[31] Padmavathi TL *et al. J Clin Diagn Res.* 2026 **20**:ZC122 [DOI: 10.7860/JCDR/2026/84974.23936]

Caveat Emptor is applicable among the literate community where required and possible. The publisher, its journal, editors and the internal/external reviewers take adequate steps to check, evaluate, correct, edit, revise and improve content where possible and required.