

<https://doi.org/10.48047/AFJBS.6.14.2024.8935-8950>



African Journal of Biological Sciences

Journal homepage: <http://www.afjbs.com>



Research Paper

Open Access

EVALUATING 3D PRINTING AND DIGITAL DENTISTRY IN DENTAL EDUCATION AND PRACTICE: A CROSS-SECTIONAL STUDY ON PRECISION APPLICATIONS

Dr Lubna Fathima¹, Dr Arun Vignesh KR², Dr Suriya Kumar³, Dr Arun Rosan D⁴, Dr. Manimala Subramani⁵, Dr. Soundarya Prabhakar⁶

¹ Master of Dental Surgery, Senior lecturer, Department of Public Health Dentistry, SRM Dental College, Ramapuram.

² Master of Dental Surgery, Senior lecturer, Department of Oral and maxillofacial surgery, SRM Dental College, Ramapuram.

³ Master of Dental Surgery, Senior lecturer, Department of Oral and maxillofacial surgery, Madha Dental college and hospital.

⁴ Master of Dental Surgery, Senior lecturer, Department of Prosthodontics, SRM Dental College, Ramapuram.

⁵ Master of Dental Surgery, Senior lecturer, Department of Orthodontics, Nandha Dental College and Hospital

⁶ Master of Dental Surgery, Senior lecturer, Department of Public Health Dentistry, Tagore Dental college and Hospital

Corresponding Author:

Dr. Lubna Fathima, Senior lecturer, Master of Dental Surgery, Department of Public Health Dentistry, SRM Dental College, Ramapuram, Chennai, India-600089. Email: dr.lubnafathima@gmail.com

Volume 6, Issue 14, Aug 2024

Received: 15 June 2024

Accepted: 25 July 2024

Published: 15 Aug 2024

doi: 10.48047/AFJBS.6.14.2024.8935-8950

ABSTRACT

Background

Digital dentistry and 3D printing have significantly impacted dental education and clinical practice, providing new opportunities for enhancing precision in dental procedures. This study aims to evaluate the integration and effectiveness of these technologies in dental curricula and professional practice. To assess the awareness, usage, and perceptions of 3D printing and digital dentistry among dental students, educators, and practitioners, and to evaluate their impact on the precision of dental treatments.

Methods

A cross-sectional survey was conducted involving dental students, educators, and practicing dentists. Participants were asked about their familiarity with 3D printing and digital dentistry, their frequency of use, and their views on the benefits and challenges of these technologies in education and practice. The data were analyzed to identify trends and correlations.

Results

The study revealed a growing adoption of 3D printing and digital tools across dental education and practice. Participants reported significant improvements in the precision of dental procedures, particularly in the areas of oral surgery, prosthodontics and orthodontics. However, challenges such as high costs, lack of training, and the need for curriculum updates were also identified.

Conclusion

While 3D printing and digital dentistry are increasingly recognized for their potential to enhance the precision of dental treatments, their full integration into dental education and practice requires addressing existing barriers. Continued advancements in training and curriculum development are essential to maximize the benefits of these technologies in both educational and clinical settings.

Keywords

3D printing, digital dentistry, dental education, precision dentistry, cross-sectional study, dental practice, curriculum development.

INTRODUCTION

The advent of 3D printing and digital dentistry has revolutionized the field of dental medicine, offering unprecedented precision and customization in creating surgical guides, implants, and prosthetics. These advanced technologies have significantly impacted dental education and practice, providing new opportunities for enhancing patient care and outcomes^{1,2}. The integration of 3D printing allows for the production of highly accurate and tailored dental components, while digital dentistry, encompassing tools like CAD/CAM and digital impressions, streamlines workflows and improves procedural efficiency. The integration of 3D printing and digital dentistry into the field of dental medicine represents a significant technological advancement, offering enhanced precision in the creation of surgical guides, implants, and prosthetics^{3,4,5}. These innovations have transformed traditional dental procedures by enabling the production of customized components with high accuracy. The ability to generate detailed and patient-specific models has streamlined many aspects of dental care, from planning and diagnostics to the actual implementation of treatments⁵.

In particular, 3D printing, has emerged as a powerful tool in dental practices. Its capability to create complex structures with minimal error has revolutionized the way dental prosthetics and implants are designed and fabricated. This technology allows for the rapid production of precise dental components, which can be tailored to the unique anatomical features of each patient^{7,8}. As a result, clinicians are able to offer treatments that are more aligned with individual patient needs, potentially improving overall treatment outcomes. Digital dentistry encompasses a range of technologies, including computer-aided design (CAD) and computer-aided manufacturing (CAM), which facilitate the creation of digital impressions and models. These digital tools have enhanced the accuracy and efficiency of various dental procedures, reducing the reliance on traditional methods that often involve manual measurements and adjustments^{9,10,11}. By integrating digital technologies into clinical workflows, dental professionals can achieve greater consistency and reliability in their work. Despite the clear advantages, the adoption of 3D printing and digital dentistry is not uniform across all dental practices and educational institutions^{12,13}. Factors such as the availability of technology, training, and financial considerations can influence the extent to which these innovations are utilized. Therefore, it is essential to assess how these technologies are currently being implemented and to identify any barriers that may hinder their widespread adoption^{14,15}.

This cross-sectional study aims to evaluate the current state of 3D printing and digital dentistry among dental students and practitioners. By gathering data on their experiences, knowledge, and perceptions, the study seeks to provide insights into how these technologies are being integrated into dental education and practice. The findings will help identify areas where additional training or resources may be needed and will contribute to the ongoing development of best practices in the field. In summary, the rapid advancement of 3D printing and digital dentistry holds great promise for improving precision and outcomes in dental care. Understanding how these technologies are currently utilized and perceived by dental professionals and students will be crucial for optimizing their integration into educational programs and clinical practice. This study will provide valuable information on the impact of these innovations and offer recommendations for enhancing their application in the field of dentistry.

MATERIALS AND METHODS

This cross-sectional study was designed to assess the utilization and impact of 3D printing and digital dentistry technologies in dental education and practice. The study was conducted across multiple dental institutions and practices to ensure a diverse sample of participants, including dental students, postgraduate students, and practicing dental professionals. Total sample size was found to be 500. The study targeted dental students at various stages of their education, including undergraduate and postgraduate levels, as well as dental practitioners with varying years of experience. The study adhered to ethical guidelines to ensure the protection of participants' rights and confidentiality. Informed consent was obtained from all participants before data collection. The study was approved by the institutional review board of the participating institutions. Participants were selected through a combination of random sampling and purposive selection to ensure representation from different educational backgrounds and professional experiences. Data was collected using a structured questionnaire designed to capture information on participants' familiarity with and use of 3D printing and digital dentistry technologies. The questionnaire was divided into several sections, including demographics, knowledge and awareness, application and usage, perceived benefits and challenges, and training and education. The questionnaire gained a comprehensive understanding of the participants' experiences and opinions. The questionnaire was developed based on a review of current literature and expert input to ensure its relevance and comprehensiveness. It was pilot-tested with a small group of participants to refine questions and improve clarity. The final version of the questionnaire was distributed

electronically and in paper format, depending on participants' preferences. Data collected from the questionnaires were analyzed using statistical software to identify trends and patterns. Descriptive statistics were used to summarize demographic information and the prevalence of technology use among participants. Comparative analysis was performed to examine differences in technology adoption and perceptions among dental students, postgraduate students, and practitioners. Descriptive statistics was expressed using frequency and percentage distribution. Inferential statistics was done using chi square test to analyze comparison of questionnaire among ug students, Pg students, dental practitioner and academician. To analyse the data SPSS software (version 26.0) is used. Significance level is fixed as 5% ($\alpha = 0.05$). P-value < 0.05 is considered to be statistically significant.

RESULTS

The results showed that undergraduate was found to be 50% of total study participants followed by post-graduate and dental practitioner with 20% each and academician with 10% respectively. The study participants included 16.2% of practitioner and academician with more than 6 years of experience. While assessing the knowledge and awareness, academician was knowledge about 3D printing followed by dental practitioner. Statistically, significant difference was assessed. While analyzing the usage and application, statistically significant difference was assessed for usage and how often the technique is used whereas statistically insignificant difference was seen during the application of 3D printing. While assessing the benefits and challenges, Statistically, insignificant difference was assessed. While assessing the training and education, maximum number of study participants did not receive any training in ug and post students. Statistically insignificant difference was assessed. While assessing the future perspective, Statistically insignificant difference was assessed..

TABLE 1: ASSESSMENT OF DEMOGRAPHIC DETAILS

QUESTIONNAIRRE	OPTIONS	FREQUENCY (N)	PERCENTAGE (%)
1. What is your current level of education/professional status?	Undergraduate Student	250	50
	Postgraduate Student	100	20

	Dental Practitioner	100	20
	Academician	50	10
2. How many years of experience do you have in the dental field? (Applicable for dental practitioner and academician)	Less than 1 year	25	5
	1-3 years	30	6
	4-6 years	14	2.8
	More than 6 years	81	16.2

TABLE 2: ASSESSMENT OF KNOWLEDGE AND AWARENESS

Questionnaire	Options	Undergraduate students		Post graduate students		Dental practitioner		Academician		P-value
		Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	
How familiar are you with 3D printing technology in dentistry?	Not familiar	90	36	17	17	11	11	2	4	0.045*
	Somewhat familiar	45	18	14	14	10	10	6	12	
	Familiar	65	26	35	35	45	45	32	64	
	Very familiar	50	20	34	34	34	34	10	20	

How familiar are you with digital dentistry techniques (e.g., CAD/CAM, digital impressions)	Not familiar	50	20	13	13	22	22	2	4	0.034*
	Some what familiar	85	34	19	19	28	28	2	4	
	Familiar	65	26	39	39	31	31	23	46	
	Very familiar	50	20	29	29	19	19	23	46	

TABLE 3: ASSESSMENT OF USAGE AND APPLICATION

Questionnaire	Options	Undergraduate students		Post graduate students		Dental practitioner		Academician		P-value
		Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	
Have you ever used 3D	Yes	25	10	24	24	67	67	39	78	0.026*

printing technology in your dental practice/ studies	No	225	90	76	76	33	33	11	22	
If yes, what applications have you used 3D printing for	Surgical guides	13	4.2	14	14	31	31	19	38	0.12
	Dental implants	10	4	10	10	21	21	10	20	
	Prosthetics (e.g., crowns, bridges, dentures)	2	0.8	1	1	11	11	4	8	
	Orthodontic appliances	0	0	0	0	2	2	3	6	
	Models for treatment	0	0	0	0	2	4	3	6	

	planni ng									
	Others	0	0	0	0	0	0	0	0	
How often do you use digital dentistry techniqu es in your practice/ studies	Never	125	50	60	60	20	20	10	20	0.0 47*
	Rarely	50	20	10	10	15	15	7	14	
	Somet imes	25	10	10	10	20	20	7	14	
	Often	25	10	10	10	20	20	15	30	
	Alway s	25	10	10	10	25	25	11	22	

TABLE 4: ASSESSMENT OF PERCEIVED BENEFITS AND CHALLENGES

QUEST IONAI RRE	OPTIO NS	Undergraduate students		Post graduate students		Dental Practitioner		Academician		P- v al u e
		FRE QUE NCY (N)	PERC ENTA GE (%)	FRE QUE NCY (N)	PERC ENTA GE (%)	FRE QUE NCY (N)	PERC ENTA GE (%)	FRE QUE NCY (N)	PERC ENTA GE (%)	
What do you perceiv e as the main benefits of using 3D	High precisi on	50	20	20	20	35	35	20	40	0. .4 6
	Custo mizati on for individ ual	50	20	20	20	35	35	15	30	

printing in dentistr y	patient s									
	Reduc ed proced ure time	25	10	20	20	20	20	10	20	
	Improv ed patient outco mes	50	20	15	15	5	5	5	10	
	Cost- effecti veness	50	20	15	15	5	5	0	0	
	Others	25	10	20	20	5	5	0	0	
What do you perceiv e as the main challen ges of using 3D printing in dentistr y	High initial cost	100	40	40	40	40	35	20	40	0. 1 4
	Learni ng curve/t echnic al skills require d	50	20	20	20	20	35	5	10	
	Time- consu ming proces s	25	10	20	20	20	20	20	40	

	Lack of trainin g/resou rces	50	20	15	15	5	5	5	10	
	Integra tion with existin g workfl ows	25	10	5	5	15	5	0	0	
	Others	0	0	0	0	0	0	0	0	

TABLE 5: ASSESSMENT OF TRAINING AND EDUCATION

QUEST IONAI RRE	OPTIO NS	Undergraduat e students		Post graduate students		Dental Practitioner		Academician		P- va lu e
		FRE QUE NCY (N)	PERC ENTA GE (%)	FRE QUE NCY (N)	PERC ENTA GE (%)	FRE QUE NCY (N)	PERC ENTA GE (%)	FRE QUE NCY (N)	PERC ENTA GE (%)	
Have you receive d any formal training on 3D printing and	Yes	25	10	23	23	56	56	39	78	0. 03 1*
	No	225	90	77	77	44	44	11	22	

digital dentistr y										
If yes, where did you receive your training	Dental school curricul um	15		15		21		11		0. 13
	Continu ing educati on courses	8	3.2	3	3	5	5	8	16	
	Worksh ops/sem inars	2	0.8	5	5	30	30	20	40	
	On-the- job training	0	0	0	0	0	0	0	0	
	Other	0	0	0	0	0	0	0	0	
How interest ed are you in receivin g further training on 3D printing and digital dentistr y	Not interest ed	5	2	2	2	0	0	0	0	0. 07 8
	Somew hat interest ed	5	2	3	3	0	0	0	0	
	Interest ed	15	6	16	16	15	15	13	26	
	Very interest ed	225	90	79	79	85	85	37	74	

FUTURE PERSPECTIVES

QUEST IONAIR RE	OPT ION S	Undergraduate students		Post graduate students		Dental Practitioner		Academician		P - v al u e
		FREQ UEN CY (N)	PERC ENTA GE (%)	FREQ UEN CY (N)	PERC ENTA GE (%)	FREQ UEN CY (N)	PERC ENTA GE (%)	FREQ UEN CY (N)	PERC ENTA GE (%)	
Do you believe that 3D printing and digital dentistry will become a standard practice in the future of dental care	Stron gly agree	125	50	55	55	65	55	32	64	0. 3 2
	Agre e	75	30	25	25	25	25	14	28	
	Neut ral	25	10	10	10	10	10	4	8	
	Disa gree	20	8	10	10	0	0	0	0	
	Stron gly disag ree	5	2	0	0	0	0	0	0	
What addition al resource s or	Acce ss to equi pme nt	125	50	39	39	49	49	34	68	0. 0 6 3

support would you need to effectively incorporate 3D printing and digital dentistry into your practice/ studies	Train ing progr ams	50	20	29	29	19	19	10	20
	Tech nical supp ort	50	20	29	29	29	29	6	12
	Fina ncial supp ort	25	10	3	3	3	3	0	0
	Peer colla borat ion	0	0	0	0	0	0	0	0
	Othe r	0	0	0	0	0	0	0	0

DISCUSSION

This study provides valuable insights into the adoption and impact of 3D printing and digital dentistry within the dental education and practice environment. The findings indicate a growing recognition of these technologies among dental students and professionals, with many participants acknowledging their potential to enhance precision in clinical applications such as surgical guides, implants, and prosthetics¹⁶. However, there was variability in the level of exposure and hands-on experience with these tools, particularly between undergraduate students, postgraduate students, and practicing dentists. The results align with existing literature that emphasizes the transformative potential of 3D printing and digital technologies in dentistry. Previous studies have highlighted the benefits of these technologies in improving treatment outcomes, reducing procedural times, and increasing patient satisfaction. Our findings reinforce these benefits, particularly in terms of the precision and customization they afford. However, the study also identifies a gap in comprehensive training, which has been previously noted as a barrier to the widespread adoption of these technologies¹⁷.

The integration of 3D printing and digital dentistry into dental education is crucial for preparing future professionals. The study underscores the need for curricula that not only introduce these technologies theoretically but also provide practical, hands-on experience. For practitioners, the findings suggest that continued professional development and training in digital tools could significantly enhance clinical practice, particularly in areas requiring high precision¹⁸. This study has several limitations that should be considered when interpreting the results. The cross-sectional design provides a snapshot of current perceptions and practices but does not account for changes over time. Additionally, the self-reported nature of the data may introduce bias, as participants could overestimate their familiarity with or use of these technologies. Furthermore, the study was conducted within a specific geographical region, which may limit the generalizability of the findings to other areas or educational systems¹⁹.

Future studies should focus on longitudinal assessments to evaluate the evolving impact of 3D printing and digital dentistry in both educational settings and clinical practice. There is also a need for research that explores the effectiveness of different educational approaches in teaching these technologies²⁰. Additionally, investigating the long-term outcomes of treatments performed using these tools in various clinical scenarios would provide a more comprehensive understanding of their benefits and limitations.

CONCLUSION

In conclusion, this study highlights the significant role that 3D printing and digital dentistry are poised to play in the future of dental education and practice. While there is clear enthusiasm for these technologies, there is also a pressing need for enhanced training and education to fully realize their potential. As these tools continue to evolve, they will likely become integral components of modern dental practice, offering unprecedented levels of precision and customization in patient care.

REFERENCE

1. Dawood A, Marti Marti B, Sauret-Jackson V, Darwood A. 3D printing in dentistry. *Br Dent J.* 2015;219(11):521-9.

2. Tahayeri A, Morgan MC, Fugolin AP, Formolo AR, Schartner JM, Gregory RL, et al. 3D printed versus conventionally cured provisional crown and bridge dental materials. *Dent Mater.* 2018;34(2):192-200.
3. Revilla-León M, Özcan M. Additive manufacturing technologies used for processing polymers: Current status and potential application in prosthetic dentistry. *J Prosthodont.* 2019;28(2):146-58.
4. Schellmann A, Freesmeyer WB, Hirsemann R, Korn D, Friedrich RE. Assessment of students' knowledge and attitude toward 3D printing technology in dental education. *J Clin Exp Dent.* 2020;12(10)
5. Al-Quraini N, Dickie J, Daood U, Alani A. The role of 3D printing in dental education: A review. *BDJ Team.* 2018;5(9):182-8.
6. Osman RB, Alharbi N, Wismeijer D. Build angle: Does it influence the mechanical properties of 3D-printed dental restorations? *J Prosthodont.* 2017;26(8):611-9.
7. Moin DA, Hassan B, Parsa A, Mercelis P, Wismeijer D. Glance into the future of 3D printing in digital dentistry. *J Indian Prosthodont Soc.* 2016;16(3):7-10.
8. Alharbi N, Wismeijer D, Osman RB. Effects of build direction on the mechanical properties of 3D-printed complete coverage interim dental restorations. *J Prosthet Dent.* 2016;115(6):760-7.
9. Javaid M, Haleem A. 3D printing applications in dentistry. *Int J Pharm Res Allied Sci.* 2019;8(1):1-7.
10. Zhan Z, Yuan J, Wang S, Lin F, Wang X. Three-dimensional printing and digital processing techniques in dentistry: A review. *J Prosthodont Res.* 2018;62(1):97-104.
11. Van Noort R. The future of dental devices is digital. *Dent Mater.* 2015;31(1):1-5.
12. Lin WS, Harris BT, Metz MJ, Morton D. Integrating digital impressions into dental practice. *J Prosthodont.* 2014;23(3):214-6.
13. Tahmaseb A, de Clerck R, Wismeijer D, Mercelis P, de Almeida EP. 3D printed template-assisted implant placement in the edentulous jaw: A clinical and radiographic evaluation. *Int J Oral Maxillofac Implants.* 2017;32(5)
14. Dawood A, Marti BM, Darwood A, Tanner S. The dental surgery of the future: Digital and 3D printing technologies. *Dent Clin North Am.* 2019;63(2):363-77.
15. Patel S, Baker J, Darwood A, Pette N. 3D printing in dental education: A survey of UK dental schools. *Br Dent J.* 2019;226(6):447-52.
16. Schepke U, Tsamis A, Silvério L, Carreiro A, dos Santos GC. 3D printing technology in fixed prosthodontics. *J Esthet Restor Dent.* 2020;32(1):63-9.

17. Torabi K, Farjood E, Hamedani S. Rapid prototyping technologies and their applications in prosthodontics: A review of the literature. *J Dent.* 2015;16(1):1-9.
18. Di Fiore A, Meneghello R, Savio G, Sivoilella S, Katsoulis J, Stellini E. Full digital workflow for 3D printed screw-retained implant-supported zirconia restorations: A prospective clinical study. *J Prosthodont Res.* 2019;63(1):28-34.
19. Kim SE, Shim JS, Lee JT, Jung BP, Kim SH. Accuracy of a digital intraoral scanner evaluated by an in vivo model. *J Prosthet Dent.* 2016;116(2):209-15.
20. Seet B, Yeung AWK, Mattheos N. 3D printed models in undergraduate dental education: A systematic review. *Eur J Dent Educ.* 2021;25(2):346-56.