RESEARCH PAPER

CAD/CAM Technology in Dental Education: A Cross-Sectional Assessment of Awareness, Knowledge, and Perceptions Among Dental Students

Dr. Aditi Bisht[1], Dr. Varun Kumar[2], Dr. Meenakshi Chaudhary[3], Dr. Geeta Arya[4], Dr. Aditi Vashisht[5], Dr. Esha Bajaj[6]

[1]Postgraduate Student, Department of Prosthodontics and Crown & Bridge, Seema Dental College and Hospital, Rishikesh, Uttarakhand, India

[2]Professor and Head, Department of Prosthodontics and Crown & Bridge, Seema Dental College and Hospital, Rishikesh, Uttarakhand, India (Corresponding Author)

Email: drvarun_smile@yahoo.co.in

[3]Reader, Department of Prosthodontics and Crown & Bridge, Seema Dental College and Hospital, Rishikesh, Uttarakhand, India

[4]Reader, Department of Prosthodontics and Crown & Bridge, Seema Dental College and Hospital, Rishikesh, Uttarakhand, India

[5]Postgraduate Student, Department of Prosthodontics and Crown & Bridge, Seema Dental College and Hospital, Rishikesh, Uttarakhand, India

[6]Postgraduate Student, Department of Prosthodontics and Crown & Bridge, Seema Dental College and Hospital, Rishikesh, Uttarakhand, India

Received: 24th May, 2026 | Revised: 20th Jun, 2026 | Accepted: 30th Jul, 2026 | Available Online: 01st Aug, 2026

ABSTRACT

Background: Computer-aided design and computer-aided manufacturing (CAD/CAM) technology has become an important component of modern digital dentistry, particularly in prosthodontics and restorative dentistry. The integration of digital impressions, computer-aided design software, and automated manufacturing systems has improved the precision and efficiency of dental restorations. Despite increasing use of CAD/CAM systems in clinical practice, awareness and knowledge of CAD/CAM technology among dental students may vary depending on their exposure during training.

Objective: The objective of the present study was to assess the awareness, knowledge, and perceptions regarding CAD/CAM technology among dental students.

Materials and Method: This cross-sectional survey was conducted among dental students (UG & PG) at Seema Dental College and Hospital, Rishikesh, Uttarakhand. A structured questionnaire consisting of 28 questions related to awareness, knowledge, and perception of CAD/CAM technology was distributed through an online platform. A total of 210 students participated in the study. The collected data were compiled using Microsoft Excel and analysed using descriptive statistics and the chi-square test to evaluate associations between awareness variables.

Results: A total of 210 dental students participated in the study, including 162 undergraduate students/interns and 48 postgraduate students. The overall survey response rate was 71.8%. Awareness of CAD/CAM technology was reported by 45.2% of participants, while 42.9% had previously seen a CAD/CAM unit. Only 26.7% correctly identified the full form of CAD/CAM, 41.4% were aware of digital impression technology, and 44.9% were aware of three-dimensional printing applications in dentistry. Despite limited knowledge and exposure, 63.8% of respondents expressed interest in learning CAD/CAM technology. A significant association was observed between academic level and CAD/CAM awareness, with postgraduate students demonstrating substantially greater awareness than undergraduate students ($p < 0.001$).

Conclusion: Awareness and knowledge of CAD/CAM technology among dental students were limited, particularly among undergraduate students. However, strong interest in learning digital dentistry highlights the need for greater integration of CAD/CAM concepts and practical training into dental curriculum to enhance preparedness for contemporary clinical practice.
Keywords: CAD/CAM technology; Digital dentistry; Dental education; Digital workflow; Prosthodontics.
How to cite this article: Bisht A, Kumar V, Chaudhary M, Arya G, Vashisht A, Bajaj E. CAD/CAM Technology in Dental Education: A Cross-Sectional Assessment of Awareness, Knowledge, and Perceptions Among Dental Students. Int J Drug Deliv Technol. 2026;16(75s): 828. DOI: 10.25258/ijddt.16.75s.96

INTRODUCTION

Digital technologies have significantly transformed modern dentistry, particularly in field of prosthodontics. Among the advancements, computer-aided design and computer-aided manufacturing (CAD/CAM) technology has emerged as an important innovation that has improved the accuracy, efficiency, and predictability of dental restorations. CAD/CAM systems allow clinicians to design and fabricate dental prostheses using digital workflows, thereby reducing the number of clinical steps involved in conventional laboratory procedures. The integration of digital scanning, computer-aided design software, and milling machines has made the fabrication of crowns, bridges, veneers, and implant prostheses more precise and time efficient.[1,2]

The concept of CAD/CAM technology was first introduced in industrial fields such as aerospace and automotive engineering and later adapted to dentistry in the early 1970s. Since then, technology has evolved rapidly with improvements in software capabilities, digital imaging, and dental materials. Early systems such as the CEREC system paved the way for chairside restorations, enabling clinicians to provide prosthetic restorations within a single clinical visit.[3] The development of intraoral scanners and advanced milling systems has further improved the accuracy of digital impressions and prosthesis fabrication.

CAD/CAM technology offers several advantages compared with conventional restorative techniques. It improves precision of restorations, reduces laboratory errors, and shortens treatment time for both clinicians and patients. In addition, CAD/CAM systems allow customization of prosthetic restorations based on individual patient anatomy and esthetic requirements. The technology also supports the use of modern restorative materials such as zirconia, lithium disilicate, and resin-based composites, which provide superior mechanical strength and aesthetic outcomes.[4,5] With the continuous advancement of digital dentistry, CAD/CAM systems are increasingly becoming an integral part of routine clinical practice.

Despite these advantages, the adoption of digital dentistry still varies among dental practitioners and students. Factors such as limited training, high equipment cost, and lack of awareness may influence the level of acceptance and clinical utilization of CAD/CAM technology.[6] Previous studies have highlighted the importance of digital education for dental professionals and students to meet modern clinical demands and improve patient care.[7-9] Assessing the awareness and knowledge of CAD/CAM systems among dental students is therefore important, as they represent the future workforce responsible for implementing digital technologies in clinical practice.

Considering the growing importance of digital workflows in restorative and prosthetic dentistry, it is essential to understand the level of awareness and knowledge among dental students. herefore, the present study was conducted to assess the awareness, knowledge, and perceptions regarding CAD/CAM technology among dental students through a structured questionnaire-based survey.

METHODOLOGY

Study Design and Setting

The present study was designed as a questionnaire-based cross-sectional survey conducted to assess the awareness and knowledge of CAD/CAM technology among dental students. The study was carried out at Seema Dental College and Hospital, Rishikesh, Uttarakhand. The study protocol received approval from the Institutional Ethics Committee of Seema Dental College and Hospital, Rishikesh. The survey was conducted using a structured questionnaire distributed through an online platform.

Study Population

The study population consisted of undergraduate and postgraduate dental students studying at Seema Dental College and Hospital. Participants who were currently enrolled in the dental program during the study period were considered eligible for inclusion. A total of 210 dental students participated in the study, which satisfied the minimum sample size requirement obtained from the power analysis.

Sample Size Estimation

Prior to the study, the required sample size was calculated using G*Power software (Version 3.1.9.7, Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany). The calculation was performed based on a chi-square test with a medium effect size (0.30), alpha error probability of 0.05, and power of 80%, which determined the minimum required sample size for the study population.

Data Collection Tool

Data were collected using a structured questionnaire consisting of 28 questions related to awareness, knowledge, and perception regarding CAD/CAM technology in dentistry. The questionnaire included multiple-choice questions addressing various aspects such as awareness of CAD/CAM technology, knowledge of its applications, materials used, advantages of the system, and its role in different branches of dentistry. The questionnaire was prepared using Google Forms and distributed electronically to the eligible participants. The online format allowed participants to respond conveniently and also ensured efficient data collection.

Data Collection Procedure

The questionnaire link was shared with dental students through online communication platforms. Participants were informed about the purpose of the study before filling out the questionnaire. Responses were automatically recorded through the Google Forms platform.

Variables Assessed

The questionnaire assessed several variables including demographic characteristics such as age and gender, awareness of CAD/CAM technology, familiarity with digital impressions and 3D printing, perception of the advantages of CAD/CAM over conventional techniques, knowledge regarding materials used in CAD/CAM systems, and understanding of the CAD/CAM workflow including scanning, designing, and milling processes.

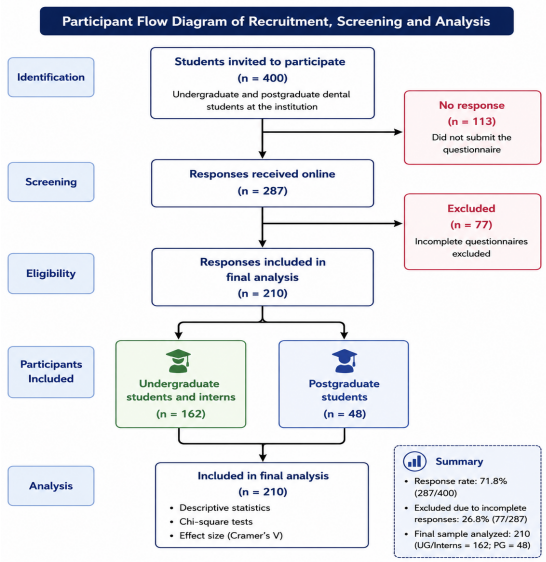

Figure 1:. Participant flow diagram illustrating recruitment and inclusion of study participants. Of the 400 dental students invited to participate, 287 responses were received. Seventy-seven incomplete questionnaires were excluded, resulting in 210 complete responses included in the final analysis.

The final study population comprised 162 undergraduate students/interns and 48 postgraduate students.

STATISTICAL ANALYSIS

Statistical analysis was performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize participant responses and are presented as frequencies and percentages. The association between academic level and awareness of CAD/CAM technology was assessed using Pearson's chi-square test. To evaluate the magnitude of the observed association, effect size was calculated using Cramer's V and interpreted according to Cohen's guidelines, where values of 0.10, 0.30, and 0.50 indicate small, medium, and large effects, respectively. Statistical significance was established at a p-value of less than 0.05. Prior to data collection, sample size estimation was conducted using G*Power software (Version 3.1.9.7, Heinrich-Heine-Universität Düsseldorf, Germany) based on a chi-square test with a medium effect size (w = 0.30), an alpha level of 0.05, and a statistical power of 80%, yielding the minimum sample size required for the study.

RESULTS

A total of 400 dental students were invited to participate in the survey. Of these, 287 responses were received, yielding an overall response rate of 71.8%. Following exclusion of 77 incomplete questionnaires, 210 complete responses were included in the final analysis (Figure 1). The final study population comprised 162 undergraduate students and interns and 48 postgraduate students. The majority of participants belonged to the 21–25 year age group (88.6%), while females constituted a larger proportion of respondents (60%) than males (40%) (Table 1). Awareness of CAD/CAM technology was reported by 45.2% of participants. Similarly, 42.9% of respondents had seen a CAD/CAM unit, while 65.2% reported that CAD/CAM technology was not included in their academic curriculum (Table 2).

Variable	Category	Frequency (n)	Percentage (%)
Age	15–20 years	20	9.5
	21–25 years	186	88.6
	26–30 years	4	1.9
	≥31 years	0	0
Gender	Male	84	40.0
	Female	126	60.0

Table 1: Demographic characteristics of the study population

Variable	Category	Frequency (n)	Percentage (%)
Awareness of CAD/CAM technology	Yes	95	45.2
	No	115	54.8
Seen a CAD/CAM unit	Yes	90	42.9
	No	120	57.1
CAD/CAM included in curriculum	Yes	73	34.8
	No	137	65.2

Table 2: Awareness and exposure to CAD/CAM technology among participants

Knowledge regarding CAD/CAM technology was assessed using questions related to its terminology and associated digital workflows. Only 26.7% of participants correctly identified the full form of CAD/CAM. Awareness of digital impression technology and three-dimensional printing technology was

reported by 41.4% and 44.9% of participants, respectively (Table 3). Interest in learning CAD/CAM technology was expressed by 63.8% of respondents, while 41.9% reported awareness of CAD/CAM-related costs and 46.7% expressed interest in incorporating CAD/CAM technology into future clinical practice (Table 4).

Variable	Category	Frequency (n)	Percentage (%)
Knowledge of full form of CAD/CAM	CAD / CAM (correct)	56	26.7
	CAD / CAM machining	79	37.6
	Computer assisted manufacturing	57	27.1
	Computer assisted machining	18	8.6
Awareness of digital impressions	Yes	87	41.4
	No	123	58.6
Awareness of 3D printing technology	Yes	94	44.9
	No	116	55.1
Awareness of CAD/CAM cost	No	122	58.1
Interested in installing CAD/CAM unit in practice	Yes	98	46.7
	No	112	53.3
CAD/CAM can improve in future	Strongly agree/Agree	59	28.1
	Neutral/Disagree	151	71.9

Table 3: Participant's Knowledge and awareness regarding CAD/CAM-related technology

Variable	Category	Frequency (n)	Percentage (%)
Interest in learning CAD/CAM	Yes	134	63.8
	No	76	36.2
	Yes	88	41.9

Table 4: Perception and attitude toward CAD/CAM technology

A statistically significant association was observed between academic level and awareness of CAD/CAM technology (χ^2 = 72.97, $p < 0.001$; Cramer's V = 0.59). All postgraduate students reported awareness of CAD/CAM technology, whereas awareness among undergraduate students and interns was considerably lower. The large effect size indicates that academic level had a substantial influence on awareness of digital dentistry concepts.

Academic Level	Aware n (%)	Unaware n (%)	Total	Chi-square (χ^2)	p value	Effect Size (Cramer's V)
UG	47 (29.0)	115 (71.0)	162	72.97	<0.001*	0.59
PG	48 (100.0)	0 (0.0)	48			

Total	95 (45.2)	115 (54.8)	210			

Pearson's chi-square test; Cramer's V interpreted according to Cohen's guidelines (0.10 = small, 0.30 = medium, and 0.50 = large effect size).

Table 5: Association Between Academic Level and Awareness of CAD-CAM Technology

DISCUSSION

The present study assessed awareness, knowledge, and perceptions regarding CAD/CAM technology among dental students and identified notable gaps in digital dentistry education. Despite the increasing adoption of CAD/CAM systems in restorative and prosthodontic practice, awareness and practical exposure among participants remained limited. Less than half of the respondents were aware of CAD/CAM technology, and many reported minimal exposure to digital workflows, suggesting that integration of digital dentistry within undergraduate education may not be keeping pace with advancements in contemporary clinical practice.[1,2]

A significant association was observed between academic level and CAD/CAM awareness, with postgraduate students demonstrating substantially greater awareness than undergraduate students. This finding indicates exposure to digital dentistry increases with advanced clinical training and supports the need for earlier introduction of CAD/CAM concepts within undergraduate curricula.

The limited awareness and knowledge observed in the present study are consistent with previous reports that identified insufficient educational exposure as a major barrier to the adoption of digital workflows in dentistry.[7,9] In addition, many participants reported that CAD/CAM technology was not formally included in their curriculum and that they had never seen a CAD/CAM unit. Such findings highlight disconnect between technological developments in clinical dentistry and the educational experiences currently available to students.[10,11]

Awareness of digital impressions and three-dimensional printing technologies was also relatively low, despite their growing importance within contemporary digital workflows. These technologies have demonstrated significant benefits in terms of efficiency, accuracy, and patient-centered care and are increasingly used across multiple dental specialties.[12–14] The limited familiarity observed among participants suggests a need for greater curricular emphasis on emerging digital technologies.

An encouraging finding was the strong interest expressed by students in learning CAD/CAM technology. Nearly two-thirds of respondents indicated a willingness to acquire knowledge and skills related to digital dentistry. Similar observations have been reported in previous studies, suggesting that student enthusiasm often exceeds the opportunities currently available for structured digital training.[7,9] This positive attitude represents an important opportunity for educational institutions to expand digital learning experiences and strengthen student preparedness for future practice.

From an educational perspective, the findings support the incorporation of competency-based training in digital workflows, including intraoral scanning, CAD software, milling systems, and additive manufacturing technologies. Structured exposure through simulation exercises, laboratory training, and clinical demonstrations may enhance both theoretical understanding and practical confidence.[9,12,15] Recent recommendations by Mun et al. further emphasize the importance of integrating digital dentistry and emerging technologies such as artificial intelligence throughout dental education to prepare graduates for technology-driven clinical environments.[16]

A major strength of the present study is the inclusion of both undergraduate and

postgraduate students, enabling comparison across different levels of training. In addition, the relatively high response rate and evaluation of awareness, knowledge, and perception provide a broad overview of digital dentistry preparedness among future dental professionals.

Certain limitations should be considered when interpreting the findings. The present study was conducted at a single institution, which may limit generalizability. Furthermore, the questionnaire was not subjected to formal psychometric validation, and the use of self-reported responses may have introduced response bias. The cross-sectional design also precludes assessment of changes in knowledge over time. Future multicenter and longitudinal studies are recommended to evaluate the effectiveness of structured CAD/CAM training programs and their impact on clinical competency and digital dentistry readiness.[7,9,17]

CONCLUSION

The present study demonstrated that awareness, knowledge, and practical exposure to CAD/CAM technology among dental students remain limited, particularly at the undergraduate level. Nevertheless, the high level of interest in learning digital dentistry highlights a favorable environment for curricular innovation. Greater integration of CAD/CAM concepts, digital workflows, and hands-on training within dental education may enhance student preparedness for contemporary technology-driven clinical practice. Curricular reforms should incorporate structured training in CAD/CAM systems, digital workflows, and emerging technologies such as artificial intelligence to ensure that future graduates are prepared for contemporary dental practice.

REFERENCES

1. Miyazaki T, Hotta Y, Kunii J, Kuriyama S, Tamaki Y. A review of dental CAD/CAM: current status and future perspectives from 20 years of experience. Dent Mater J. 2009;28(1):44-56.
2. Beuer F, Schweiger J, Edelhoff D. Digital dentistry: an overview of recent developments for CAD/CAM generated restorations. Br Dent J. 2008;204(9):505-11.
3. Moörmann WH. The evolution of the CEREC system. J Am Dent Assoc. 2006;137(Suppl):7S-13S.
4. Fasbinder DJ. Chairside CAD/CAM: an overview of restorative material options. Compend Contin Educ Dent. 2012;33(1):52-58.
5. Chunara F, Dehankar SP, Sonawane AA, Kulkarni V, Bhatti E, Samal D, Kashwani R. Advancements in biocompatible polymer-based nanomaterials for restorative dentistry: exploring innovations and clinical applications: a literature review.
6. Schweiger J, Edelhoff D, Güth JF. 3D printing in digital prosthetic dentistry: an overview of recent developments in additive manufacturing. J Clin Med. 2021;10(9):2010.
7. Mittal A, , Sapra S, Savita B, Roy B, , Midha A. 3D Printing in Dentistry: A Narrative Review. Oral Sphere J. Dent. Health Sci. 2025;1(4):263-267. doi: 10.63150/osjdhs.2025.28
8. Mangano F, Gandolfi A, Luongo G, Logozzo S. Intraoral scanners in dentistry: a review of the current literature. BMC Oral Health. 2017;17(1):149.
9. Umer MF, Faheemuddin M, Alshehri YA, Alqosaibi AA, Alojail AA, Althani AA, Alnaim MA, Alharbi SA. Assessment of digital dentistry knowledge and practices among dental students at King Faisal University, Saudi Arabia. Med Sci Monit. 2024;30:e944692.
10. Alghazzawi TF. Advancements in CAD/CAM technology: options for practical implementation. J Prosthodont Res. 2016;60(2):72-84.

11. Van Noort R. The future of dental devices is digital. Dent Mater. 2012;28(1):3-12.
12. 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.
13. Kashwani R, Ahuja G, Narula V, Jose AT, Kulkarni V, Hajong R, Gupta S. Future of dental care: integrating AI, metaverse, AR/VR, teledentistry, CAD & 3D printing, blockchain and CRISPR innovations. Community Pract. 2024;21(5):123-37.
14. Javaid M, Haleem A. Current status and applications of additive manufacturing in dentistry: a literature-based review. J Oral Biol Craniofac Res. 2019;9(3):179-85.
15. Schlenz MA, Schmidt A, Wöstmann B, Krämer N, Schulz-Weidner N. Students' and lecturers' perspective on the implementation of digital dentistry in undergraduate dental education. BMC Med Educ. 2020;20:207.
16. Mun M, Mariño R, Hopcraft M, Kotsanas G, Calache H. Digital dentists: a curriculum for the 21st century. JMIR Med Educ. 2025;11:e54153.
17. Joda T, Gallucci GO, Wismeijer D, Zitzmann NU. Augmented and virtual reality in dental medicine: a systematic review. Comput Biol Med. 2019;108:93-100.