

Exploring The Digital Era: Dentists Perspective On CAD-CAM Technology

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Abstract:

Background: Computer-Aided Design and Computer-Aided Manufacturing (CAD-CAM) technologies have transformed restorative and prosthetic dentistry by enhancing precision, efficiency, and esthetics. However, their widespread adoption remains variable, especially in developing regions due to cost and training barriers. This study aimed to assess the awareness, usage patterns, and perceptions of CAD-CAM technology among dental professionals in Andhra Pradesh and Telangana, India.

Materials and Methods: A cross-sectional questionnaire-based survey was conducted among 145 dental professionals using an online Google Forms platform. The structured questionnaire comprised 25 items across seven sections assessing demographics, awareness, workflow implementation, perceived advantages, limitations, and future perspectives on CAD-CAM technology. Data were analyzed descriptively, and post hoc power analysis using GPower confirmed statistical adequacy (power > 0.85).

Results: Among the participants, 92.4% were aware of digital dentistry, and 75.2% reported using CAD-CAM technology, primarily for crown and bridge fabrication (82.1%) and implant prostheses (71.0%). The most preferred CAD-CAM materials were zirconia (87.6%) and lithium disilicate (39.3%). High equipment cost (65.5%) and need for additional training (39.3%) were the main barriers to adoption. The majority (92.4%) agreed that CAD-CAM improved precision and efficiency, while 74.5% expressed interest in attending further hands-on training programs. A significant proportion (69.7%) recommended CAD-CAM prostheses for superior long-term outcomes compared to conventional methods.

Conclusion: The findings reveal high awareness and positive attitudes toward CAD-CAM technology among dental professionals, though actual usage remains limited by economic and educational factors. Integrating CAD-CAM modules into dental curricula, providing affordable access to digital infrastructure, and organizing continuing education programs are critical steps to facilitate broader clinical adoption in the dental sector.

Key Word: CAD-CAM, Digital Dentistry, Prosthodontics, Awareness, Dental Technology.

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I. Introduction

Over the past two decades, CAD/CAM technology has become essential in digital dentistry. It's used to fabricate restorations like crowns, veneers, bridges, and implant abutments, both chairside and in labs. Orthodontics also benefits from CAD/CAM for aligners and custom appliances.¹ The technology addresses three key challenges: ensuring strength (especially for posterior restorations), achieving natural esthetics, and improving efficiency through precise digital workflows. Systems like CEREC now enable same-day restorations, enhancing both patient experience and clinical accuracy.² CAD/CAM technology has greatly improved comfort, efficiency, and restoration quality for both dentists and dental technicians. Compared to conventional methods, CAD/CAM restorations are more durable, offer better marginal fit, superior esthetics, and faster fabrication times. However, high initial costs remain a barrier, particularly in developing countries, where many practitioners are hesitant to adopt the technology. Despite this, the clinical benefits such as improved precision in fabricating inlays, onlays, crowns, bridges, implant abutments, and fixed partial dentures are significant and continue to advance with ongoing innovation.^{2,3} Dentistry dates back to ancient times, with early dental practices recorded by figures like Hippocrates. Major innovations include porcelain teeth, amalgam fillings, and gold foil techniques. CAD/CAM technology, based on Euclidean geometry, originated with Dr. Hanratty's CAM system and Sutherland's CAD software. In dentistry, Dr. Duret pioneered CAD/CAM crowns in 1971, and Dr. Mörmann introduced the first commercial CEREC system in 1985 for same-day restorations. In the 1980s, Dr. Andersson

developed the Procera system using titanium as a metal alternative. Subsequent CEREC versions expanded restoration options and added virtual occlusal adjustment. Although CAD/CAM offers precision and speed, its high cost and complexity have limited widespread adoption.³

I. Materials and Methodology

Study Design: The cross-sectional study was conducted between professionals making use of an online platform to perform the survey.

Sample of Study : The study obtained 145 dentists who has been practising in Andhra Pradesh and Telangana.

Instrument of Study: The demographic data related to questions are among the online questionnaire including knowledge and attitude towards CAD/CAM and its applications. The questionnaire consisted of closed-ended questions and one open-ended question. Google forms were utilized as a mode of questionnaire building and distributing. Data were kept confidential and stored until their use.

The sample size of 145 participants was determined to be adequate based on post hoc power analysis using GPower (version 3.92). The achieved power ($1-\beta$) was estimated to be between 0.85 and 0.95 for detecting medium effect sizes (Cohen's $w = 0.3$ for chi-square tests or $d = 0.5$ for mean comparisons) at a significance level of $\alpha = 0.05$. This indicates that the study had sufficient statistical power (>80%) to detect meaningful differences in awareness and usage patterns among dental professionals, consistent with standard practices in questionnaire-based dental research.

The questionnaire consists of 7 sections and a total of 25 questions.

QUESTIONNAIRE

Section 1: Demographic Information

1. What is your specialization?

- a. General Dentist
- b. Prosthodontist
- c. Endodontist
- d. Orthodontist
- e. Pedodontist
- f. Oral surgeon
- g. Periodontist
- h. Oral radiologist
- i. Community dentist
- j. Other: _____

2. What is your level of clinical experience?

- a. Less than 5 years
- b. 5-10 years
- c. 10-15 years
- d. 15-20 years
- e. More than 20 year

3. What is your primary practice setting?

- a. Private Practice
- b. Academic Institution
- c. Hospital-Based Practice
- d. Mixed Practice

4. Are you aware of Digital Dentistry?

Yes or No

5. How many years have you been using CAD-CAM technology?

- a. Less than 1 year
- b. 1-3 years
- c. 3-5 years
- d. More than 5 years
- e. Never used

Section 2: Awareness & Usage of CAD-CAM

1. How familiar are you with CAD-CAM?

(scale: 1 = Not at all familiar, 5 = Very familiar)

2. When did you first learn about CAD/CAM technology?

- a. During undergraduate education
- b. During postgraduate education
- c. Conferences/Workshops
- d. Social media/Online platforms
- e. Colleagues/Dental practice
- f. Other: _____

3. Which CAD-CAM systems or software do you use? (multiple answers)

- a. Cerec
- b. 3Shape
- c. Exocad
- d. Medit Link
- e. Planmeca
- f. Others (Please specify)

4. According to your knowledge, what are the main applications of CAD/CAM in dentistry? (Select all that apply)

- a. Crown and Bridge fabrication
- b. Implant Prosthesis
- c. Complete Denture
- d. Removable Partial Denture
- e. Inlays/Onlays
- f. Veneers
- g. Orthodontic Appliances
- h. Surgical Guides
- i. Other: _____

5. Do you believe CAD/CAM can improve the quality and efficiency of prosthodontic treatment?

- a. Strongly Agree
- b. Agree
- c. Neutral
- d. Disagree
- e. Strongly Disagree

Section 3: Workflow & Implementation

How do you use CAD-CAM in your practice? (any one)

- a. In-house CAD-CAM milling
- b. Outsourced to a lab
- c. Both in-house and outsourced

2. Do you perform digital impressions in your practice?

Yes or No

3. What are the biggest challenges you face when using CAD-CAM? (multiple answers)

- a. High cost
- b. Learning curve
- c. Accuracy concerns
- d. Need for additional training
- e. Patient acceptance
- f. Software/hardware limitations

4. Which CAD-CAM materials do you prefer most commonly? (multiple answers)

- a. Zirconia
- b. Lithium Disilicate (e.max)
- c. PMMA
- d. PEEK

e. Hybrid Ceramics

f. Titanium

Section 4: Perceived Benefits & Limitations

1. On a scale of 1–5, how do you rate the precision of CAD-CAM prostheses compared to conventional methods?

(scale: 1 = Poor, 5 = Excellent)

2. What are the top advantages of using CAD-CAM? (multiple answers)

a. Faster turnaround time

b. Improved fit and precision

c. Reduced chair-side adjustments

d. Better patient experience

e. Predictable results

3. What are the limitations of CAD-CAM? (multiple answers)

a. High initial cost

b. Need for retraining

c. Material limitations

d. Difficulty in complex cases

Section 5: CAD-CAM in Implants

1. Do you use CAD-CAM for implant prosthodontics?

Yes or No

2. If yes, Which of the following CAD/CAM components for implants are you familiar with? (Select all that apply)

a. Custom Abutments

b. Screw-retained Prosthesis

c. Implant Surgical Guide

d. Full-arch Implant Prosthesis

e. Hybrid Prosthesis

f. Temporary Restorations

g. Other: _____

3. If no, what is the primary reason you do not use CAD/CAM in implant prosthesis fabrication?

a. High cost of CAD/CAM equipment

b. Lack of training/knowledge

c. Time-consuming learning process

d. Limited patient affordability

e. Prefer conventional methods

f. Other: _____

Section 6: Future of CAD-CAM technology

1. Do you think CAD-CAM will completely replace conventional techniques in the future? (any one)

a. Yes

b. No

c. Not Sure

2. What improvements would you like to see in CAD-CAM technology? (multiple answers)

a. Lower cost

b. Better material choices

c. More intuitive software

d. Faster production times

3. Would you prefer attending a workshop or hands-on training for CAD/CAM technology?

a. Yes

b. No

c. Maybe

Section 7: Final Remarks

1. Would you recommend CAD/CAM prosthesis over conventional methods for long-term success and patient satisfaction?

- a. Yes
- b. No
- c. Not Sure

2. Any additional comments or suggestions regarding CAD/CAM in dentistry?

II. Results

A total of 145 dental professionals participated in this questionnaire-based study.

Demographic Profile - The participants' age ranged from 20 to 55 years, with a mean of 29.78 ± 5.44 years. Among them, 64.8% (n = 94) were male and 35.2% (n = 51) were female.

Professional Background - With respect to specialization, the majority were general dentists (50.3%), followed by prosthodontists (17.9%), endodontists (8.3%), orthodontists (6.9%), oral surgeons (5.5%), oral radiologists (5.5%), periodontists (2.8%), pedodontists (1.4%), and community dentists (1.4%). In terms of clinical experience, 60.7% had less than 5 years, 24.1% had 5–10 years, 11.7% had 10–15 years, and only 3.4% had 15–20 years of practice experience. Regarding practice setting, private practice was the most common (43.4%), followed by academic institutions (33.8%), mixed practice (11.7%), and hospital-based practice (11.0%).

Awareness and Familiarity with CAD-CAM - A vast majority (92.4%) were aware of digital dentistry (fig.1). With respect to CAD-CAM usage, 17.2% had never used the technology, while 33.8% had used it for less than 1 year, 31.0% for 1–3 years, 6.9% for 3–5 years, and 11.0% for more than 5 years. Self-rated familiarity on a 5-point scale showed that the largest proportion rated themselves at 3 (29.7%), followed by 2 (22.8%), 5 (19.3%), 4 (15.2%), and 1 (13.1%).

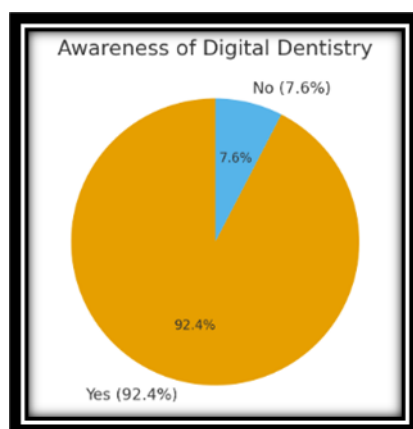


Fig.1: Awareness of Digital Dentistry

When asked about the source of learning, 44.8% first encountered CAD-CAM during undergraduate training, followed by postgraduate education (29.0%), colleagues/dental practice (14.5%), conferences/workshops (7.6%), and social media/online platforms (3.4%). Only 0.7% reported they had never heard of CAD-CAM.

CAD-CAM Systems and Applications - Among systems used, Exocad (53.1%) was the most commonly employed, followed by Cerec (40.0%), 3Shape (32.4%), Medit Link (17.2%), and Planmeca (11.0%). The most frequently cited applications were crown and bridge fabrication (82.1%) and implant prosthesis (71.0%). Other applications included inlays/onlays (55.9%), veneers (55.2%), complete denture fabrication (45.5%), surgical guides (40.7%), removable partial dentures (40.0%), and orthodontic appliances (35.9%).

Perceptions Toward CAD-CAM - Regarding its role in prosthodontics, 92.4% of participants either agreed or strongly agreed that CAD-CAM improves quality and efficiency, with 60.0% strongly agreeing and 32.4% agreeing. When asked about implementation, the majority (68.3%) outsourced CAD-CAM work to laboratories, 17.2% had in-house CAD-CAM facilities, and 14.5% used a mixed model. Furthermore, 79.3% reported routinely performing digital impressions in practice.

Challenges and Materials - The most significant challenge reported was high cost (65.5%), followed by need for additional training (39.3%), software/hardware limitations (35.2%), learning curve (32.4%), accuracy concerns (28.3%), and patient acceptance (27.6%).(fig.2)

The most preferred CAD-CAM restorative material was zirconia (87.6%), followed by lithium disilicate (39.3%), titanium (33.1%), hybrid ceramics (26.2%), PMMA (22.1%), and PEEK (17.9%).(fig.3)

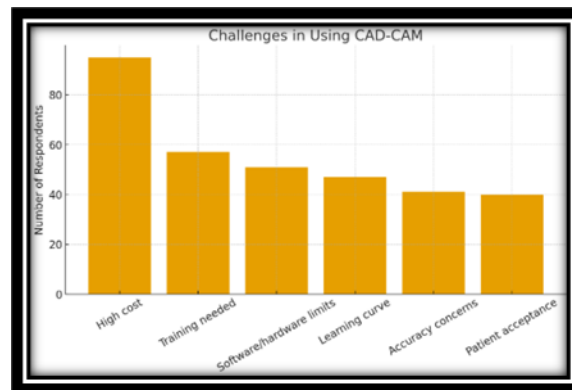


Fig.2: Challenges in using CAD-CAM

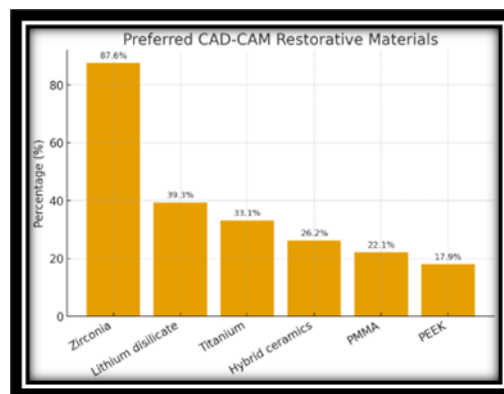


Fig.3: preferred CAD-CAM restorative materials

When asked to rate the precision of CAD-CAM prostheses versus conventional methods, the majority rated 4 (37.9%) and 5 (33.8%), suggesting high confidence in the technology

Advantages and Limitations - Respondents identified improved fit and precision (72.4%), better patient experience (64.8%), reduced chairside adjustments (60.7%), and faster turnaround times (53.8%) as the major advantages.(fig.4)

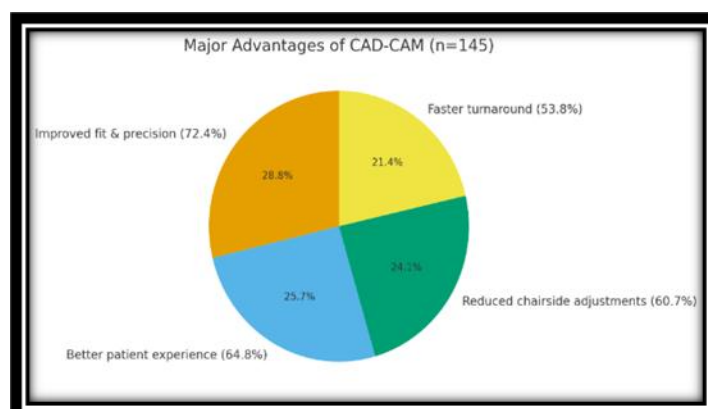


Fig.4: Major advantages of CAD-CAM

However, limitations were also acknowledged, with high initial cost (85.5%) being the most significant, followed by material limitations (39.3%), difficulty in complex cases (37.9%), and the need for retraining (37.9%).(fig.5)

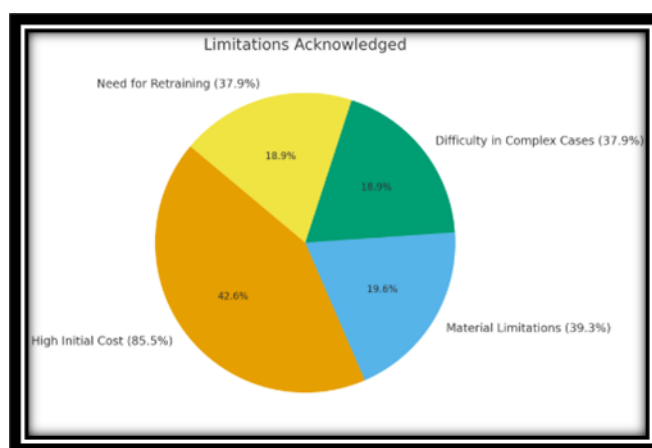


Fig.5: Limitations Acknowledged

CAD-CAM in Implant Prosthodontics - A total of 75.2% of participants used CAD-CAM for implant prosthodontics. Among them, the most common applications included screw-retained prosthesis (46.9%), custom abutments (45.5%), full-arch prostheses (45.5%), and surgical guides (40.0%). Among the 24.8% who did not use CAD-CAM for implants, the primary reasons were high equipment cost (47.6%), limited patient affordability (35.9%), lack of training (30.3%), preference for conventional methods (13.8%), and time-consuming learning process (13.8%).(fig.6)

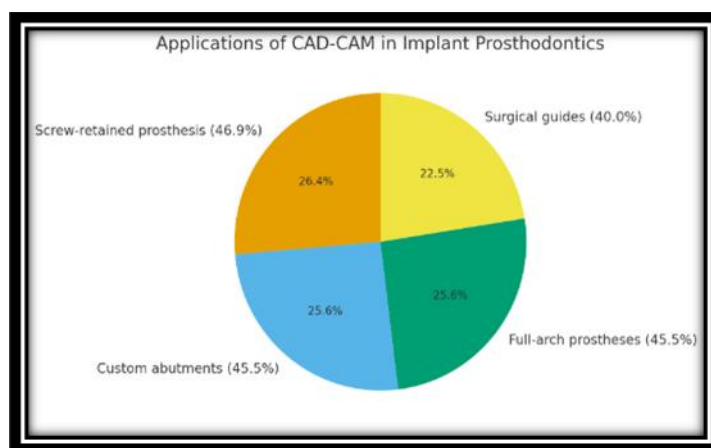


Fig.6: Applications of CAD-CAM in Implant Prosthodontics

Future Outlook and Training Needs - When asked about the future of CAD-CAM, 44.8% believed it would completely replace conventional techniques, 33.1% said maybe, and 22.1% did not think so. Respondents suggested several areas for improvement, including lower costs (67.6%), more intuitive software (51.7%), better material options (48.3%), and faster production times (32.4%). In terms of professional development, 74.5% expressed interest in attending workshops or hands-on training on CAD-CAM technology. Importantly, 69.7% recommended CAD-CAM prostheses over conventional methods for long-term patient satisfaction and treatment success.

Open Comments - Qualitative responses highlighted cost as the major barrier to wider adoption. Other comments emphasized the need for more training, user-friendly software, and material affordability. Some respondents stressed the importance of making CAD-CAM more adaptable for complex and edentulous cases, while others expressed optimism about its role in the future of dentistry.

III. Discussion

This questionnaire-based study assessed awareness, utilization, and perceptions of CAD-CAM technology among dental professionals. The results demonstrate high awareness (92.4%) but variable adoption, reflecting similar global trends in digital dentistry integration. Our findings align with Nassani et al. (2021)⁴, who reported high awareness of CAD-CAM among general dentists but limited chairside usage, indicating that while digital dentistry is widely recognized, barriers to full implementation remain. In the present study, 75.2% of participants reported CAD-CAM use for implant prosthodontics, similar to the results of Krastev et al. (2023)⁵ and Blackwell et al. (2017)⁶, who found that crown and bridge fabrication and implant restorations were the most common applications worldwide.

Zirconia (87.6%) was the most preferred restorative material among participants, consistent with Robaian et al. (2024)¹⁹⁽⁷⁾ and Lawson et al. (2021)²⁰⁽⁸⁾, who identified zirconia as the dominant CAD-CAM material due to its high strength, esthetics, and machinability. The preference for zirconia and lithium disilicate underscores the growing reliance on advanced ceramics for predictable long-term outcomes. Perceived advantages of CAD-CAM technology included improved fit and precision (72.4%), reduced chairside adjustments (60.7%), and enhanced patient satisfaction (64.8%). These findings support the observations of Ille et al. (2025)⁹ and Mühlemann et al. (2022)¹⁰, who reported superior marginal accuracy and time efficiency for CAD-CAM restorations compared to conventional methods. However, barriers remain significant. High equipment cost (65.5%), need for additional training (39.3%), and software/hardware limitations (35.2%) were the main constraints. Similar findings were reported by Alqahtani et al. (2021)¹¹ and Reddy et al. (2023)¹², where cost and lack of technical expertise were the predominant deterrents. The preference for outsourcing (68.3%) rather than maintaining in-house systems further reflects the financial challenges of adopting digital infrastructure in smaller practices. Educational exposure played a critical role in familiarity in which 44.8% of participants learned about CAD-CAM during undergraduate training, and 74.5% expressed interest in further workshops. This aligns with Witjes et al. (2018)¹³ and Seikaly et al. (2019)¹⁴ who emphasized the integration of CAD-CAM training in dental curricula and continued professional education to enhance digital competence. In summary, awareness and attitude toward CAD-CAM are high, and practitioners recognize its clinical and esthetic benefits. However, economic barriers, limited training, and technical complexities hinder universal implementation. Broader access to affordable systems, structured education, and software improvements could enhance adoption rates in clinical dentistry.

IV. Limitations

The cross-sectional nature of the study limits the ability to establish causal relationships. The sample size (n = 145) may not represent the entire dental population, and responses were self-reported, potentially leading to bias in estimating actual usage and competence.

V. Recommendations

Training: Introduce CAD-CAM modules in undergraduate and postgraduate programs.

Affordability: Encourage institutional support and shared digital laboratory facilities.

Research: Conduct longitudinal outcome studies comparing CAD-CAM and conventional workflows.

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