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Exploring student awareness on digital prosthodontics: A questionnaire-based study

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Abstract
Digital dentistry has revolutionized prosthodontic practice through technologies such as CAD/CAM systems, intraoral scanners, and 3D printing. Understanding student awareness and preparedness for these technologies is essential for curriculum development. This cross-sectional questionnaire-based study aimed to assess knowledge, awareness, practice, and perceived barriers regarding digital prosthodontics among dental students. A validated questionnaire comprising 14 items across three domains (Knowledge, Awareness/Practice, and Barriers) was distributed to 216 dental students across all academic years. Data were analyzed using descriptive statistics, chi-square tests, and two-way ANOVA. Results showed that 88% of participants were aware of digital dentistry, with lectures being the primary source of information (18%). However, only 12% had practical experience with CAD/CAM technology. While 94% believed digital dentistry reduces treatment time and 96% expressed interest in using CAD/CAM technology in the future, significant knowledge gaps existed regarding specific materials (24% correct) and fabrication timelines (5% correct). Cost of equipment and lack of knowledge/training emerged as primary barriers. Statistical analysis revealed highly significant associations between study variables ($p<0.0001$). The study highlights the need for enhanced practical training and curriculum updates to bridge the gap between theoretical knowledge and hands-on experience in digital prosthodontics.

Keywords: Digital dentistry, CAD/CAM, Dental education, Prosthodontics, Intraoral scanner, 3D printing, Student awareness

Introduction
The integration of digital technologies into dentistry has fundamentally transformed clinical practice, particularly in the field of prosthodontics. Computer-aided design/computer-aided manufacturing (CAD/CAM) technology, intraoral scanners, cone-beam computed tomography (CBCT), and 3D printing have become increasingly significant tools in modern dental practice, offering enhanced precision, efficiency, and patient outcomes. These technologies have streamlined the workflow for fabricating dental prostheses, reducing chair time and improving the accuracy of restorations. [1, 2, 3]

The adoption of digital dentistry in educational settings has become imperative to prepare future dental professionals for contemporary clinical practice. Several dental institutions worldwide have begun incorporating digital workflows into their curricula, allowing students to experience both conventional and digital approaches to prosthodontic treatment. [4, 5, 6] This integration enables students to understand the advantages and limitations of each method, facilitating informed decision-making in their future practice. Despite the growing implementation of digital technologies in dental education, studies have shown that many dental students still lack sufficient knowledge and practical experience with these systems. [7, 8] The gap between theoretical understanding and hands-on competence poses challenges for graduates entering a profession that increasingly relies on digital workflows. Understanding the current state of student awareness, knowledge, and perceived barriers is essential for developing effective educational strategies.

This study aimed to comprehensively assess dental students' awareness regarding digital prosthodontics, evaluate their knowledge levels across different academic years, examine their practical exposure to CAD/CAM technologies, and identify the primary barriers to adoption. The findings will provide valuable insights for curriculum development and educational planning in dental institutions.

Materials and Methods
1. Study Design and Participants
This cross-sectional questionnaire-based study was conducted among dental students at a dental institution. The study included undergraduate dental students from all academic years (1st through final year) as well as intern. Participants were informed about the aims of the study, and their consent for participation was obtained prior to questionnaire distribution. The study was conducted in accordance with ethical guidelines, and institutional approval was obtained before commencement.

2. Questionnaire Development and Validation
A structured questionnaire was developed based on previous validated studies in the field of digital dentistry education. [7, 8] The questionnaire was designed to assess three primary domains: Knowledge (Q1-Q6), Awareness and Practice (Q7-Q11, Q13), and Barriers (Q12, Q14). The instrument comprised 14 questions covering awareness of digital dentistry terminology, sources of knowledge acquisition, familiarity with specific technologies, understanding of materials used

in CAD/CAM systems, practical experience, attitudes toward future adoption, and perceived barriers to implementation.
For validation purposes, the questionnaire was reviewed by faculty members specializing in prosthodontics and dental education. A pilot study was conducted with a randomly selected sample of students to assess clarity and comprehensibility. Based on feedback received, necessary modifications were made to ensure the questionnaire effectively captured the intended constructs. The final validated questionnaire was then distributed to participants.

3. Scoring and Interpretation

The scoring system was established as follows: For Knowledge assessment, scores were categorized as High (≥70% of maximum score), Moderate (40-69%), or Low (<40%). For Awareness and Practice, responses were classified as Good (≥4 out of 6 positive responses), Fair (2-3 positive responses), or Poor (0-1 positive responses). Barrier perception was categorized as Low (0-1 barriers identified), Moderate (2-3 barriers), or High (≥4 barriers identified).

4. Statistical Analysis

The collected data were analyzed using appropriate statistical software. Descriptive statistics including means, standard deviations, frequencies, and percentages were calculated for all variables. Chi-square tests were employed to examine associations between categorical variables. Two-way ANOVA was used to compare mean scores across different academic year levels. A p-value of less than 0.05 was considered statistically significant.

Results

1. Demographic Characteristics

A total of 216 dental students participated in this study. The demographic characteristics of the participants are presented in Table 1. The distribution across academic years showed that third-year students comprised the largest group (n=83, 38.42%), followed by first-year students (n=76, 35.18%), second-year students (n=22, 10.18%), third-year students (n=83, 38.42%), fourth-year students (n=9, 4.17%) and interns (n=26, 12.04%). The gender distribution revealed a predominance of female participants (n=168, 77.78%) compared to male participants (n=48, 22.22%).

Table 1: Demographic Details of Study Participants (n=216)

Variables	No. of Participants	Percentage (%)
Year of Study		
1st Year	76	35.18
2nd Year	22	10.18
3rd Year	83	38.42
4th Year	9	4.17
Interns	26	12.04
Gender		
Male	48	22.22
Female	168	77.78

2. Knowledge Assessment

The knowledge assessment results are summarized in Table 2. A high proportion of participants (88%) demonstrated awareness of the term "digital dentistry" (Q1). However, when asked about the source of their study knowledge, only 18% correctly identified lectures as their primary learning source, while 82% indicated other sources or were uncertain (Q2). Regarding familiarity with specific technologies in digital dentistry, 61% demonstrated correct awareness (Q3). Knowledge gaps were more pronounced in specific technical areas. Only 24% of participants correctly identified materials used in CAD/CAM technology (Q4). While 85% correctly acknowledged that dentures can be fabricated using CAD/CAM technology (Q5), only 5% demonstrated accurate understanding of fabrication timelines (Q6). Practical experience was notably low, with only 12% reporting having worked with CAD/CAM in their practice or training (Q7). Chi-square analysis revealed a highly significant association between knowledge variables (χ^2=310.2, df=6, p<0.0001).

Table 2: Knowledge Assessment of Study Participants (n=216)

Knowledge Item	Correct Response (%)	Incorrect/Not Aware (%)
Q1: Aware of digital dentistry	88%	12%
Q2: Source of study knowledge	18%	82%
Q3: Technologies of digital dentistry	61%	39%
Q4: Materials used in CAD/CAM	24%	65%
Q5: Denture fabrication using CAD/CAM	85%	16%
Q6: Time to fabricate denture using CAD/CAM	5%	95%
Q7: Worked with CAD/CAM in practice	12%	88%

Chi-square test: χ^2=310.2, df=6, p<0.0001

3. Awareness and Practice Assessment

The awareness and practice assessment results are presented in Table 3. A substantial majority of participants (94%) believed that treatment time is reduced in digital dentistry compared to conventional methods (Q8). However, only 20% strongly agreed that digital dentistry improves treatment quality, while 80% remained neutral or disagreed (Q9). Regarding future intentions, 74% expressed willingness to practice digital dentistry in their future careers (Q10), and an even higher proportion (96%) indicated interest in using CAD/CAM technology specifically (Q11). When asked about the accuracy of digital designs, 88% agreed that digital dentistry provides accurate designs required for treatment (Q12). However, fewer participants (27%) demonstrated comprehensive understanding of the specific capabilities (Q13). Notably, only 4% reported having regular access to digital dentistry facilities (Q14). Chi-square analysis demonstrated highly significant associations among awareness and practice variables (χ^2=386.3, df=6, p<0.0001). Analysis of barriers revealed that cost of equipment, lack of knowledge/training, and limited availability were identified as the primary obstacles to adopting digital dentistry in prosthodontics. Accessibility issues and other factors were also reported as contributing barriers. The barrier perception scores indicated that while students recognized these challenges, most demonstrated low to moderate barrier perception, suggesting optimism about overcoming these obstacles in the future.

Table 3: Awareness, Practice Assessment and Barriers of Study Participants (n=216)

Awareness/Practice Item	Positive Response (%)	Negative Response (%)
Q8: Time reduced vs conventional	94%	6%
Q9: Improves quality of treatment	20%	80%
Q10: Practice digital dentistry in future	74%	26%
Q11: Use CAD/CAM in future	96%	4%
Q12: Accurate designs for treatment – Barriers question	88%	12%
Q13: Understanding of capabilities	27%	73%
Q14: Regular access to facilities – Barriers question	4%	96%

Chi-square test: $\chi^2=386.3$, df=6, $p<0.0001$

4. Comparison of Scores Across Academic Years

Table 4 presents the comparison of knowledge, awareness, and barrier scores across different academic years. Knowledge scores remained relatively consistent across most year levels, ranging from 4.89±0.15 (Interns) to 5.0±0.18 (4th year). Awareness scores showed progressive improvement from lower to higher academic years, with interns demonstrating the highest mean score (2.98±0.09) compared to first-year students (2.73±0.10). Barrier perception scores also showed slight variation, with interns reporting the highest barrier perception (1.70±0.18). Two-way ANOVA analysis revealed statistically significant differences among groups ($p<0.0001$).

Table 4: Comparison of Scores Among Study Participants by Academic Year

Year of Study	Knowledge Score (Mean ± SD)	Awareness Score (Mean ± SD)	Barrier Score (Mean ± SD)
1st Year	4.878 ± 0.14	2.73 ± 0.10	1.59 ± 0.15
2nd Year	4.875 ± 0.14	2.74 ± 0.10	1.58 ± 0.14
3rd Year	4.88 ± 0.14	2.76 ± 0.10	1.60 ± 0.15
4th Year	5.00 ± 0.18	4.00 ± 0.09	1.00 ± 0.10
Interns	4.89 ± 0.15	2.98 ± 0.09	1.70 ± 0.18

Two-way ANOVA: $p<0.0001$

Discussion

This study provides comprehensive insights into dental students awareness, knowledge, and attitudes toward digital prosthodontics. The findings reveal a complex picture where high general awareness coexists with significant gaps in specific technical knowledge and practical experience. These results have important implications for dental education curriculum development.

The high awareness rate (88%) of digital dentistry terminology among participants is encouraging and reflects the increasing prominence of digital technologies in contemporary dental discourse. This finding aligns with previous studies reporting similar levels of general awareness among dental students. [5, 7, 8] However, the disparity between general awareness and specific knowledge highlights a critical educational gap. Only 24% of participants correctly identified materials used in CAD/CAM technology, and merely 5% understood fabrication timelines accurately. These findings suggest that while students are familiar with digital dentistry as a concept, their understanding of practical applications remains limited. The low rate of practical experience (12%) with CAD/CAM technology is a concerning finding that warrants attention. [9] Despite 96% of participants expressing interest in using CAD/CAM technology in their future practice, the current educational experience appears insufficient to prepare them for this transition. This disconnect between aspiration and preparation represents a significant challenge for dental institutions. Previous studies have emphasized that practical exposure during undergraduate training significantly influences graduates' willingness and ability to adopt new technologies in practice. [6]

The progressive improvement in awareness scores from lower to higher academic years, with interns demonstrating the highest scores (2.98±0.09), suggests that accumulated clinical exposure contributes to better understanding of digital technologies. This finding supports the importance of integrating digital workflow experiences throughout the curriculum rather than concentrating them in specific courses. The significantly higher awareness among interns may reflect their exposure to clinical environments where digital technologies are increasingly utilized. The identification of cost of equipment, lack of knowledge/training, and limited availability as primary barriers reflects challenges commonly reported in dental education literature. [4, 10] These barriers are interconnected: institutions may lack equipment due to cost constraints, which in turn limits training opportunities for students. Addressing these barriers requires strategic institutional investment and potentially collaborative arrangements with industry partners to enhance student exposure to digital technologies.

The finding that 94% of participants believe digital dentistry reduces treatment time compared to conventional methods indicates positive perceptions that could facilitate technology adoption. [11] However, only 20% strongly agreed that digital dentistry improves treatment quality, suggesting that students may view these technologies primarily as efficiency tools rather than quality enhancers. [12, 13] Educational programs should emphasize both aspects to provide a balanced understanding of digital dentistry benefits. The highly significant statistical associations found in both knowledge ($\chi^2=310.2$, $p<0.0001$) and awareness/practice assessments ($\chi^2=386.3$, $p<0.0001$) underscore the validity of the observed patterns. These associations indicate that students' responses were not random but reflected systematic patterns related to their educational exposure and understanding of digital prosthodontics.

Several limitations of this study should be acknowledged. The study was conducted at a single institution, which may limit generalizability of findings. The uneven distribution of participants across academic years, particularly the low representation of fourth-year students (n=1), may affect the reliability of comparisons. Additionally, the cross-sectional design captures only a snapshot of student awareness at one point in time, and longitudinal studies would provide better insights into how awareness develops throughout dental education. Future research should include multi-institutional studies with larger sample sizes to enable more robust comparisons across academic years and institutions. Investigation of specific interventions, such as dedicated digital dentistry courses or hands-on workshops, would help identify effective strategies for improving student preparedness. Additionally, studies examining the correlation between undergraduate exposure and subsequent adoption of digital technologies in clinical practice would provide valuable long-term outcome data.

Conclusions

This study reveals that dental students possess high general awareness of digital dentistry (88%) and demonstrate strong interest in utilizing these technologies in their future practice (96%). However, significant gaps exist between theoretical awareness and practical competence, with only 12% having hands-on experience with CAD/CAM technology. Knowledge deficits were particularly evident in specific technical areas such as materials (24% correct) and fabrication timelines (5% correct).

The progressive improvement in awareness scores from lower to higher academic years indicates that clinical exposure contributes positively to understanding digital technologies. Cost of equipment, lack of knowledge/training, and limited availability were identified as the primary barriers to digital dentistry adoption.

Based on these findings, dental institutions should prioritize increasing practical training opportunities in digital prosthodontics, updating curriculum content to include comprehensive coverage of digital workflows and materials, and addressing infrastructure barriers through strategic investment and industry partnerships. Bridging the gap between student awareness and practical competence is essential for preparing graduates to meet the demands of an increasingly digitalized dental practice environment.

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