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Dental Students' Awareness Regarding the Implementation of Digital Dentistry in Prosthodontics—A Questionnaire-Based Study

Mohammed M. Gad [1], Sujood S. Al Shehab [2], Farah Y. Alshaikhnasser [2], Shaymaa Y. Alboryh [2], Ali I. Alkhalaf [3], Soban Q. Khan [4], Basmah O. Alakloby [2], Hind M. Alharbi [2], Nada Alhorish [5], Shoug Alrajhi [6], Khalid S. Al-Abidi [1], Mohamed S. Ali [1], Yousif A. Al-Dulaijan [1,*] and Shaimaa M. Fouda [1]

1 Department of Substitutive Dental Sciences, College of Dentistry, Imam Abdulrahman Bin Faisal University, P.O. Box 1982, Dammam 31441, Saudi Arabia; mmjad@iau.edu.sa (M.M.G.); kalabidi@iau.edu.sa (K.S.A.-A.); msali@iau.edu.sa (M.S.A.); smfouda@iau.edu.sa (S.M.F.)
2 College of Dentistry, Imam Abdulrahman Bin Faisal University, P.O. Box 1982, Dammam 31441, Saudi Arabia; 2180002405@iau.edu.sa (S.S.A.S.); 2180004807@iau.edu.sa (F.Y.A.); 2180002447@iau.edu.sa (S.Y.A.); 2180000826@iau.edu.sa (B.O.A.); 2180002417@iau.edu.sa (H.M.A.)
3 Department of Cariology, Restorative Sciences and Endodontics, University of Michigan-School of Dentistry, 1011 N. University Avenue, Ann Arbor, MI 48109, USA; alkhalaf@umich.edu
4 Department of Dental Education, College of Dentistry, Imam Abdulrahman Bin Faisal University, P.O. Box 1982, Dammam 31441, Saudi Arabia; sqkhan@iau.edu.sa
5 Dental Department, Ministry of Health, Dammam 32254, Saudi Arabia; nada.alhorish.1@gmail.com
6 Dental Department, King Saud Hospital, Qassim Health Cluster, Qassim 52738, Saudi Arabia; alrajhishoug@gmail.com
* Correspondence: yaaldulaijan@iau.edu.sa; Tel.: +966-13-333-1462

Abstract: Background: Computer-aided design/computer-aided manufacturing (CAD-CAM) technology is becoming a more significant means of providing prosthodontic treatment due to its impact on clinical performance and patient outcomes. It has been integrated into dental education to allow students to experience digital work-flows. Despite these advancements, many dental students still lack sufficient knowledge of CAD-CAM technologies. Methods: A cross-sectional survey was conducted at the College of Dentistry, Imam Abdulrahman Bin Faisal University. Based on previous studies, a validated questionnaire was distributed to undergraduate dental students and interns. The questionnaire assessed their knowledge and attitudes toward CAD-CAM technology in prosthetic dentistry. Statistical analysis software utilized in the study was the Statistical Package for Social Sciences (SPSS). Results: The responses were analyzed using descriptive statistics, and a chi-square test was used to study the association between knowledge and practice and the study year level. A total of 170 students participated in the study, with a mean age of 22.2 (±2.5) years. The proportion of female participants was 65.9% and the proportion of males was 34.1%. Knowledge varied across academic levels, with fourth- and fifth-year students demonstrating greater theoretical knowledge, while sixth-year students and interns showed more practical experience. Only 3 of the 18 knowledge-related questions received a correct response rate above 70%. Most participants (86%) reported acquiring knowledge from undergraduate courses, and 88% expressed interest in further training. Conclusions: CAD-CAM technology was most commonly practiced for fixed prostheses, and intraoral scanning was the most frequently used digital work-flow. The study highlights the need to improve CAD-CAM education. While lower-level students displayed solid theoretical knowledge, advanced students benefitted from more practical exposure. Increasing hands-on experience and access to digital equipment is essential for preparing students to meet the demands of modern digitalized dentistry.

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1. Introduction

It is essential to provide suitable education on computer-aided design/computer-aided manufacturing (CAD-CAM) technology due to its growing significance in prosthodontic treatment. Some dental schools have incorporated this CAD-CAM into dental students' education as a new concept [1]. This incorporation enables students in preclinical programs to evaluate the differences between conventional and digital impressions and experience restoration fabrication utilizing a digital work-flow [1,2].

Tele-dentistry integrates telecommunications and dentistry, facilitating the remote exchange of clinical information and images [3]. With advanced technology, dental education programs are paying more attention to the role of digitalization in most educational programs [4]. In addition, students' attitudes toward implementing digital technology in dentistry curricula with varied levels of penetration permit these technologies to be applied in dental practice and educational programs [5]. A recent assessment of digitalization in dental education revealed its potential to enhance the preparation of future dentists for their everyday practices [6]. Additionally, emerging interactive and intuitive e-learning options are expected to create an engaging and significant educational experience with improved tools, likely becoming central to the future of dentistry education [6]. Therefore, high-quality user training is essential for successful CAD-CAM technology implementation in patient care [2]. Moreover, digital techniques and work-flows are vital in the education of dental students [7]. Schlenz et al. highlighted that students view the introduction of digital dentistry in the preclinical curriculum positively [7].

Regarding digital learning and assessment resources, mobile devices, teledentistry, and various social media platforms can indicate their knowledge level in the field and the necessity for integrating technology into the current dental education system, benefiting teaching and learning [4]. Moreover, implementing digital education in the curriculum is helpful for instruction in CAD-CAM dental restoration [8]. Wu et al. [9] recommended the digital evaluation system as a part of dental education due to its accessibility, which enriches and enhances the teaching process, introducing new insights for clinical practice and education.

Moreover, integrating CAD-CAM technology in dentistry has significantly enhanced clinical performance and patient care quality [10,11]. By automating the design and fabrication of dental restorations, CAD-CAM systems have greatly improved dental prostheses' precision, efficiency, and aesthetic quality [10]. The digital work-flow facilitates data acquisition through intraoral scanners, reducing the need for traditional impressions and shortening the turnaround time for restorations [11]. Further, materials such as zirconia, resin composites, and ceramic blocks used in CAD-CAM systems offer superior mechanical properties, enhancing the durability and functionality of restorations [10,11]. These materials have demonstrated consistent clinical performance in prosthetic and restorative applications, contributing to long-term patient stability and comfort [10]. Moreover, CAD-CAM-produced restorations exhibit excellent biocompatibility, strength, and esthetics, making them a highly favorable option in modern dentistry [10,11].

With the widespread use of CAD-CAM technology, it should be incorporated into undergraduate courses, including preclinical and clinical courses, allowing students to practice and gain the necessary knowledge for its application in clinical settings [12]. By recognizing the value of this technology, students will be more likely to adopt it in everyday practice in their future clinical work [12]. This survey aims to detect undergraduate students' awareness (knowledge and practice) about the application of CAD-CAM technology in prosthodontics.

2. Materials and Methods

The participants were informed about the aims of this study, and their consent for participation was obtained. The study was conducted at the College of Dentistry, Imam Abdulrahman Bin Faisal University, after IRB approval (IRB-2022-02-229). Undergraduate dental students and interns at the College of Dentistry, IAU, were included in this study. The undergraduate students in the clinical years (4th year, 5th year, and 6th year) were invited to participate in the study. Hence, all male and female clinical-year students and interns working at the College of Dentistry were invited to participate in the study; therefore, the sample size was not required to be calculated [13]. A total of 170 students and interns were voluntarily enrolled in the study, and all of them filled out the survey; hence, the response rate was 100%.

A validated questionnaire was prepared based on previous studies [7,13,14]. The questionnaire covered all necessary information regarding three commonly studied categories in digital work-flow for different types of dental prosthesis fabrication, including intraoral scanner for digital impression, as well as complete denture fabrication using the subtractive method (milled denture) and the additive method (3D-printed denture). The designed questionnaire included information regarding the machines, materials, and various techniques. All participants completed the questionnaire, which consisted of three sections. The first section gathered general participant data (age, gender, and level of education). The second section included 24 questions designed to evaluate students' knowledge of CAD-CAM. The third part was designed to evaluate the students' attitudes and different practices of CAD-CAM technology.

For validation, additional steps were taken by randomly selecting students and prosthodontic faculty members to review the questionnaire [15]. Based on the feedback from the randomly selected sample and faculty responses, the questionnaire was revised and modified accordingly. After questionnaire modification and validation procedures, the questionnaire was distributed physically by a research team to the attended students of each class level in a classroom and re-collected once they completed the questionnaire.

The responses to the knowledge section questions were collected as "yes, no, and not sure". However, after the completion of data collection, the correct answer for each question was coded as "good", and the remaining responses were marked as "poor". Hence, the responses to each knowledge question were transformed as "good or poor", as described previously [13].

The statistical analysis software used in the study was Statistical Package for Social Sciences (SPSS v.23, IBM Corp., New York, NY, USA). In the descriptive analysis of the data, means, standard deviations, frequencies, percentages, and bar diagrams were used. For the inferential data analysis, the chi-square test was used to study the association between knowledge and practice questions with the study year level of the participants. All p-values less than 0.05 were considered statistically significant.

3. Results

The response rate was 100% as the questionnaire was collected immediately after all invited participants were completed. A total of 170 dental students were included in this study, with a mean age of 22.2 (±2.5) years. The proportion of female participants was higher than male participants, with 112 females (65.9%) and 58 males (34.1%). In terms of academic-year levels, Figure 1 illustrates the distribution of participants across the different academic years.

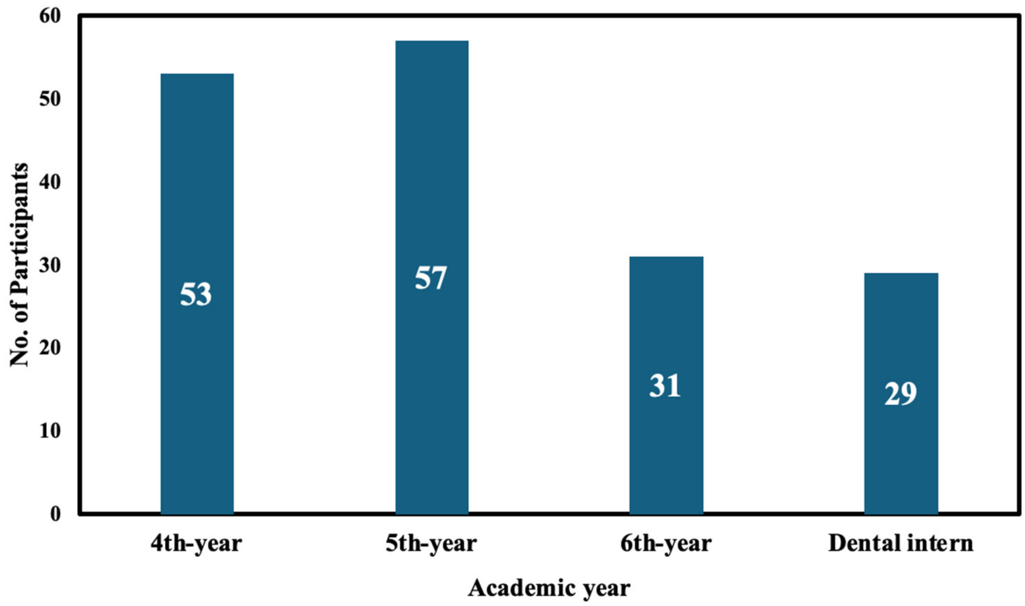

Figure 1. Number of participants.

Only 3 of the 18 knowledge-related questions received a correct response rate of 70% or higher. Question 4 received the lowest correct response rate, with only 25 participants (14.8%) out of 170 answering it correctly (Table 1).

Table 1. Knowledge questions responses.

Questions	Good No. (%)	Poor No. (%)
Q1: Is digital intraoral impression required for CAD-CAM fabrication of dental restorations?	89 (52.4)	81 (47.6)
Q2: Is digital impression recommended for all prosthodontics situations without any limitations?	115 (67.6)	55 (32.4)
Q3: Is intraoral scanner used exclusively to scan tissues intraorally?	67 (39.4)	103 (60.6)
Q4: Does intraoral scanning produce more accurate digital casts than lab scanner?	25 (14.8)	144 (85.2)
Q5: Is the use of intraoral scanners easier than lab scanners?	58 (34.1)	112 (65.9)
Q6: Are the steps for intraoral scanning used to produce fixed and removable prostheses the same?	54 (32)	115 (68)
Q7: Can complete dentures be made/fabricated using CAD-CAM technology in two visits?	78 (45.9)	92 (54.1)
Q8: Is CAD-CAM technology more precise than conventional techniques for the same dental procedure?	115 (67.6)	55 (32.4)
Q9: Does CAD-CAM technology produce faster restoration than conventional methods?	144 (85.7)	24 (14.3)
Q10: Can three-dimensional (3D) printing technique be used for complete denture fabrication?	119 (70)	51 (30)
Q11: Are milled and 3D-printed technologies same for scanning denture fabrication?	63 (37.1)	107 (62.9)

Table 1. *Cont.*

Questions	Good No. (%)	Poor No. (%)
Q12: Are milled and 3D-printed technologies same for designing denture fabrication?	65 (38.2)	105 (61.8)
Q13: Are milled and 3D-printed technologies same for production denture fabrication?	53 (31.2)	117 (68.8)
Q14: Are denture base materials used for milling and 3D-printed technologies the same?	63 (37.5)	105 (62.5)
Q15: Are there differences in the mechanical properties of the PMMA used for conventional heat-polymerized, CAD-CAM milled or 3D-printed removable dentures?	72 (42.4)	98 (57.6)
Q16: Can removable partial dentures be digitally designed?	120 (71.4)	48 (28.6)
Q17: Can removable partial denture be fabricated using subtractive technology?	81 (47.6)	89 (52.4)

Table 2 presents a comparison between year-level and knowledge-related questions. It was observed that fourth- and fifth-year students had a higher rate of correct responses for 8 out of 18 questions. In contrast, sixth-year students and interns had a higher rate of correct responses for the remaining ten questions. Additionally, statistical significance was identified in questions 3, 5, and 11. For question 3, a significantly higher proportion (49.1%) of fifth-year students answered the correct answer compared to students of other year levels ($p = 0.044$). For question 5, sixth-year students had a significantly higher proportion (54.8%) of correct responses than other year levels. Furthermore, in question 11, 57.9% of fifth-year students answered it correctly, with their proportion significantly higher than that of different year levels ($p = 0.001$).

Table 2. Comparison of knowledge with study year level.

Questions	Responses	Year Level				*p*-Value
		4th	5th	6th	Intern	
Q1	Good Poor	34 (64.2) 19 (35.8)	29 (50.9) 28 (49.1)	11 (35.5) 20 (64.5)	15 (51.7) 14 (48.3)	0.088
Q2	Good Poor	33 (62.3) 20 (37.7)	39 (68.4) 18 (31.6)	21 (67.7) 10 (32.3)	22 (75.9) 7 (24.1)	0.657
Q3	Good Poor	23 (43.4) 30 (56.6)	28 (49.1) 29 (50.9)	6 (19.4) 25 (80.6)	10 (34.5) 19 (65.5)	0.044 *
Q4	Good Poor	7 (13.2) 46 (86.8)	7 (12.5) 49 (87.5)	5 (16.1) 26 (83.9)	6 (20.7) 23 (79.3)	0.757
Q5	Good Poor	10 (18.9) 43 (81.1)	21 (36.8) 36 (63.2)	17 (54.8) 14 (45.2)	10 (34.5) 19 (65.5)	0.009 *
Q6	Good Poor	16 (30.8) 36 (69.2)	17 (29.8) 40 (70.2)	11 (35.5) 20 (64.5)	10 (34.5) 19 (65.5)	0.937
Q7	Good Poor	23 (43.4) 30 (56.6)	28 (49.1) 29 (50.9)	18 (58.1) 13 (41.9)	9 (31) 20 (69)	0.187
Q8	Good Poor	33 (62.3) 20 (37.7)	42 (73.7) 15 (26.3)	19 (61.3) 12 (38.7)	21 (72.4) 8 (27.6)	0.471
Q9	Good Poor	45 (88.2) 6 (11.8)	45 (78.9) 12 (21.1)	29 (93.5) 2 (6.5)	25 (86.2) 4 (13.8)	0.266

Table 2. *Cont.*

Questions	Responses	Year Level				*p*-Value
		4th	5th	6th	Intern	
Q10	Good Poor	33 (62.3) 20 (37.7)	41 (71.9) 16 (28.1)	29 (83.9) 5 (16.1)	19 (65.5) 10 (34.5)	0.193
Q11	Good Poor	13 (24.5) 40 (75.5)	33 (57.9) 24 (42.1)	9 (29) 22 (71)	8 (27.6) 21 (72.4)	0.001 *
Q12	Good Poor	20 (37.7) 33 (62.3)	28 (49.1) 29 (50.9)	9 (29) 22 (71)	8 (27.6) 21 (72.4)	0.147
Q13	Good Poor	12 (22.6) 41 (77.4)	23 (40.4) 34 (59.6)	12 (38.7) 19 (61.3)	6 (20.7) 23 (79.3)	0.096
Q14	Good Poor	21 (40.4) 31 (59.6)	21 (37.5) 35 (62.5)	14 (45.2) 17 (54.8)	7 (24.1) 22 (75.9)	0.366
Q15	Good Poor	25 (47.2) 28 (52.8)	24 (42.1) 33 (57.9)	14 (45.2) 17 (54.8)	9 (31) 20 (69)	0.546
Q16	Good Poor	33 (63.5) 19 (36.5)	43 (75.4) 14 (24.6)	24 (80) 6 (20)	20 (69) 9 (31)	0.357
Q17	Good Poor	27 (50.9) 26 (49.1)	27 (47.4) 30 (52.6)	13 (41.9) 18 (58.1)	14 (48.3) 15 (51.7)	0.887
Q18	Good Poor	29 (55.8) 23 (44.2)	38 (66.7) 19 (33.3)	21 (67.7) 10 (32.2)	14 (48.3) 15 (51.7)	0.275

* indicates a level of significance.

Table 3 summarizes the CAD-CAM practices of all participants. In total, 86% of participants reported acquiring information from undergraduate courses, 58% gained it theoretically, and 41% received theoretical knowledge and hands-on experience. Most participants (70%) indicated that CAD-CAM teaching and training were beneficial, and 88% expressed interest in receiving further training on CAD-CAM practices. Meanwhile, 79% of participants had not attended any extracurricular training.

Table 3. Distribution of practice responses.

Questions	Responses	No. (%)
Q5: Were you taught about the different uses of CAD-CAM technology in your undergraduate courses?	Yes No	146 (86.4) 23 (13.6)
Q5a: If yes, what type of teaching/training was provided?	Theoretical only Theoretical and hands-on training	89 (58.9) 62 (41.1)
Q5b: Was teaching/training useful?	Yes No	109 (70.8) 45 (29.2)
Q6: Are you interested in learning more about CAD-CAM?	Yes No	149 (88.2) 20 (11.8)
Q7: Did you attend any extracurricular education courses dedicated for CAD-CAM training?	Yes No	34 (20.2) 134 (79.8)
Q8: Did you work with CAD-CAM technology before in your practice?	Yes No	47 (28) 121 (72)
Q8a: Which element of CAD-CAM technology did you work with?	Fixed dental prostheses Removable dental prostheses Oral appliances Occlusal devices Pediatric (space maintainer)	50 (58.1) 11 (12.8) 17 (19.8) 7 (8.1) 1 (1.1)
Q8b: Which element of CAD-CAM technology did you work with?	Digital intraoral impressions Laboratory scanning of models and impressions Performing CAD Performing CAM	65 (54.2) 23 (19.2) 22 (18.3) 10 (8.3)

Table 3. *Cont.*

Questions	Responses	No. (%)
Q8c: If no, what was the reason for not using CAD-CAM?	Non-availability of CAD-CAM	64 (39.2)
	Non-accessibility to CAD-CAM	7 (4.3)
	Inferior quality of restorations	35 (21.5)
	I am not very technologically aware	44 (27.0)
	No advantages of CAD-CAM	3 (1.8)
	Other	10 (6.1)
Q8d: How many fixed dental CAD-CAM prostheses did you fabricate during the last year?	None	133 (80.1)
	1–2	24 (14.5)
	3–5	6 (3.6)
	6–10	2 (1.2)
	More than 10	1 (0.6)
Q8d How many removable dental CAD-CAM prostheses did you fabricate during the last year?	None	150 (90.4)
	1–2	11 (6.6)
	3–5	4 (2.4)
	6–10	1 (0.6)
	More than 10	0
Q9: What materials do you regularly use with CAD-CAM?	Strengthened ceramics	32 (16.4)
	Composite	8 (4.1)
	Metals	8 (4.1)
	Polycrystalline ceramics	22 (11.3)
	I do not use CAD-CAM	91 (46.7)
	I do not know	34 (17.5)
Q10: Within the CAD-CAM work-flow, which elements do you feel need improvement in order to facilitate and streamline your work?	Intra or extra oral scanning	46 (23.3)
	Cad design on computer	30 (15.2)
	CAM manufacture of prostheses	23 (11.6)
	I do not know	98 (49.7)
Q11: Do you think it is important to implement CAD-CAM technology in dental practice?	Yes for all specialties	83 (49.7)
	Yes for some specialties	71 (42.7)
	Yes for dental restorations only	4 (2.4)
	No	9 (5.4)
Q12: Do you plan to use CAD-CAM technology in the future?	Yes	156 (93.4)
	No	11 (6.6)
Q13: Which of the following materials can be used in CAD-CAM technology for denture base fabrication?	Metal	71 (17.1)
	Zirconium	69 (16.7)
	Light polymerized acrylic resin	88 (21.3)
	PMMA	33 (8.0)
	Wax	103 (24.9)
	Fluid resin	50 (12.1)

A small percentage of participants reported practicing CAD-CAM, with the highest frequency of use for fixed dental prostheses compared to removable prostheses and other dental devices. Intraoral digital impressions were the most commonly practiced element of the digital work-flow, with 54% of participants practicing them. Among those utilizing CAD-CAM in clinics, the average of two completed cases was found, with fixed dental prostheses being more prevalent than removable ones.

There was an equal distribution of responses regarding CAD-CAM technologies, materials, and digital work-flows, though many participants selected the "I don't know" response. However, most participants suggested incorporating CAD-CAM technology into all dental specialties and advocating for additional courses and hands-on training following their initial exposure to CAD-CAM.

A comparison between study year levels and the practice-related questions is summarized in Table 4. Responding to question 5a, a significantly higher proportion of sixth-year students reported receiving theoretical education or training ($p < 0.001$). Additionally, when students were asked about the usefulness of the education or training (Q5b), a significantly higher proportion of sixth-year students disagreed, stating that it was not useful ($p = 0.000$). When asked about the previous use of CAD-CAM technology, 69% of interns responded affirmatively, which was significantly higher than other year levels ($p = 0.000$) (Table 4).

Table 4. Practice responses in comparison with the study year level.

Questions	Responses	Year Level				p-Value
		4th	5th	6th	Intern	
Q5	Yes No	41 (77.4) 12 (22.6)	51 (91.1) 5 (8.9)	26 (83.9) 5 (16.1)	28 (96.6) 1 (3.4)	0.051
Q5a	Theoretical only Theoretical and hands-on training	15 (34.9) 28 (65.1)	39 (75) 13 (25)	24 (88.9) 3 (11.1)	11 (37.9) 18 (62.1)	0.000 *
Q5b	Yes No	37 (84.1) 7 (15.9)	36 (66.7) 18 (33.3)	11 (40.7) 16 (59.3)	25 (86.2) 4 (13.8)	0.000 *
Q6	Yes No	48 (90.6) 5 (9.4)	47 (83.9) 9 (16.1)	29 (93.5) 2 (6.5)	25 (86.2) 4 (13.8)	0.527
Q7	Yes No	9 (17) 44 (83)	14 (25.5) 41 (74.5)	4 (12.9) 27 (87.1)	7 (24.1) 22 (75.9)	0.461
Q8	Yes No	12 (22.6) 41 (77.4)	11 (20) 44 (80)	4 (12.9) 27 (87.1)	20 (69) 9 (31)	0.000 *
Q12	Yes No	47 (90.4) 5 (9.6)	51 (92.7) 4 (7.3)	30 (96.8) 1 (3.2)	28 (96.6) 1 (3.4)	0.604

* indicates a level of significance.

4. Discussion

CAD-CAM technology has increasingly permeated across all specialties of the dental field, offering high-quality, digitally fabricated prostheses with clinically acceptable performance [2,7,13]. Accordingly, assessing the level of awareness and practical engagement of CAD-CAM technology among undergraduate students is crucial [6,16]. The findings of this questionnaire-based study indicate significant variations in both the awareness and practice of CAD-CAM and digital dentistry across different student levels. While it was expected that higher-level students would possess greater knowledge and practical experience, the results reveal that fourth- and fifth-year students exhibited a higher level of knowledge compared to their senior counterparts. However, practical experience was more prevalent among students at the advanced levels.

The higher level of knowledge observed in lower-level students may be attributed to their ability to effectively memorize the recently acquired information in updated courses that incorporate more digital dentistry implementations. In agreement with a previous study [13], it was reported that "Although undergraduate knowledge of CAD-CAM technology has improved, further education on its clinical applications is crucial to ensure students are fully prepared for the evolving field of digital dentistry" [6,7,17]. In earlier years, due to the emergence of new systems and devices, higher-level students exhibited a lower level of knowledge compared to those enrolled in the last three years. The widespread adoption of digital dentistry, driven by increasing competition among companies, the variety of systems available, and the greater accessibility of information, has provided an opportunity to acquire more knowledge that has since been integrated into the curriculum as a core component of CAD-CAM technologies. A previous study by Gratton et al. [18] investigated students' knowledge of CAD-CAM technologies related to different levels and found that lower-level students exhibited greater theoretical knowledge due to the recent incorporation of updated digital dentistry content into their courses.

In contrast, higher-level students had more practical experience with CAD-CAM technologies [7]. This distinction reflects the curriculum structure, where lower-level students are exposed to foundational concepts, whereas higher-level students gain hands-on experience in clinical settings. However, despite their practical exposure, the study noted that higher-level students still lacked up-to-date theoretical knowledge, likely due to the rapid advancements in digital technologies and the evolving nature of the field. This gap highlights the importance of continuously updating the curriculum's theoretical and practical components to ensure students are fully equipped for digital dentistry [7].

The findings of our study showed that participants have "good" knowledge based on their responses to three questions (Q9, Q10, and Q16). CAD-CAM technology was introduced to overcome problems associated with conventional techniques, such as faster processes, saving materials, and design and fabrication using 3D-printed technology [19]. Our findings (scored 70% good or more) support this fact. In contrast, the participants scored "poor" knowledge regarding one question (Q4) related to different types of digital scanners. Additional efforts are needed to familiarize undergraduate students with various digital scanners. Furthermore, most participants demonstrated limited knowledge of the technologies related to other knowledge questions regarding the digital fabrication of prostheses and production technology. There were also noted gaps in the understanding of differences between devices used in the digital work-flow and their applications [7,14]. This highlights the need for greater emphasis on the digital work-flow, from scanning to fabrication, tailored to each dental specialty. A previous study [13] investigated students' knowledge of CAD-CAM technologies and found that, while awareness had improved, gaps remained in their understanding of practical clinical applications, highlighting the need for enhanced training to equip future dentists for digital dentistry.

In terms of CAD-CAM technology practice, three questions (Q5, Q5b, and Q6) showed high scores (>70% good). These responses reflect the participants' level of education; hence, digital dentistry was integrated into our curriculum. Additionally, the participants were interested in learning more about CAD-CAM (Q6). However, attending extracurricular activities showed a low score (Q7, 20.2%). This should encourage all dental education levels to implement more extracurricular activities related to CAD-CAM technology [20,21]. The majority of participants demonstrated a good level of practical experience. Most reported receiving information and motivation to practice CAD-CAM through the curriculum, continuous education at the undergraduate level, and participation in various workshops [22]. This highlights the importance of implementing CAD-CAM training and, accordingly, course requirements for digitally fabricated cases [23,24]. Furthermore, the higher levels of practical experience seen among students can be attributed to their exposure to a broader range of clinical cases, as well as their use of digital labs [25]. This is in agreement with studies that emphasize the positive impact of practical experience and clinical exposure on skill development, which reported that practical learning environments accelerate the application of CAD-CAM technology in clinical settings, leading to improved competence among students [13]. However, in disagreement with previous studies, which suggested that the theoretical knowledge gained from lectures alone was sufficient for students to develop CAD-CAM skills, the importance of direct clinical experience and digital lab work was underestimated. The results of this study underscore the need for a balanced approach that combines both theoretical knowledge and practical exposure to prepare students for the demands of digital dentistry fully [6].

Most participants utilized CAD-CAM technology to fabricate various prostheses, particularly fixed ones. However, the number of digitally treated cases per participant was relatively low, likely due to the limited availability of digital equipment. Those who used CAD-CAM for prosthesis fabrication reported positive feedback, higher satisfaction, and more straightforward treatment procedures than conventional methods [11,26]. Participants also noted high levels of patient satisfaction, attributing this to the efficiency of the digital work-flow and the clinical outcomes of digitally fabricated prostheses [27]. Bhaskar et al. concluded that students who are aware of digital denture systems, such as CAD-CAM dentures, reduce both clinical chair time and the number of patient visits [22].

In our study, 54% of participants identified intraoral digital impressions as the most prevalent element of the digital work-flow, and using CAD-CAM technology for creating fixed dental prostheses garnered the highest response rate at 58.1%. This preference may stem from the accessibility and simplicity of the systems and machines designed for fabricating fixed prostheses, often considered superior to removable options. Research by Ishida et al., aimed at assessing the integration of CAD-CAM technology in creating complete and partial dentures among dental students in the US, revealed that complete CAD-CAM dentures are included in the curriculum for 54.2% of undergraduates and 65.2% of postgraduate residents [28]. In contrast, removable CAD-CAM partial dentures are covered in only 37.5% of undergraduate courses and 47.8% of postgraduate curricula, likely due to constraints such as limited funding, resources, time, and faculty availability for teaching CAD-CAM in removable prosthodontics [28].

The drawbacks of additively manufactured prosthetic materials and technologies, including expensive equipment and materials, limited material options, technological limitations, complex design, and lack of practical experience, present obstacles to using CAD-CAM in prosthetics. Addressing these limitations can significantly improve the efficiency, accuracy, and outcomes of prosthetic CAD-CAM applications. Likewise, advancements in material science and post-processing methods can significantly enhance the quality, precision, and durability of additively fabricated prostheses, making them more reliable and accessible [16,25,29]. It was reported in the literature that two technologies are used for prosthesis fabrications: subtractive and additive [28,30,31]. In the present study, the participants practiced both technologies with a limited selection of materials. They used milled ceramic materials for fixed prosthesis fabrication, while other materials such as titanium, titanium alloys, and chrome cobalt alloys were not used. This may be due to the lack of a system for these materials or the machine used for fabrication, as reported in previous studies [10,31]. By addressing these gaps, the implementation of CAD-CAM technology in dental education can be more effective, ensuring that students are prepared for clinical practice in an increasingly digitalized field of dentistry.

With the widespread adoption of digital dentistry, there is a growing demand for updated knowledge and practical experience across different educational levels. According to the findings of this study, while digital dentistry has been incorporated into prosthodontic courses at various undergraduate levels, there remains a need for further updates and the integration of new materials. Furthermore, the positive feedback from participants practicing and treating patients using digital methods emphasizes the clinical significance of this study. Additionally, it would be interesting to match teledentistry with smartphone applications [32] and artificial intelligence [33] to improve data and knowledge on the reliability of teledentistry-based programs in daily clinical practice.

The present study provides essential information regarding dental students' knowledge and skills in digital dentistry. However, the results cannot be generalized due to the relatively small number of participants and the inclusion of students from a single college of dentistry, which is considered a limitation of the present study. Future studies involving more participants from various colleges of dentistry are needed to allow the study results to be compared and generalized. Another potential limitation is that the effects on students' awareness and knowledge retention in the intermediate and long term have not yet been explored.

5. Conclusions

Dental students possess a good understanding of digital dentistry in prosthodontics, with lower-level students demonstrating a higher theoretical knowledge and higher-level students exhibiting good practical skills. However, the digital work-flow of prosthesis fabrication, from scanning and designing to the final fabrication process, needs to be further emphasized as a core component of the curriculum for undergraduate students at all levels.

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