Original article

Awareness Among Dental Undergraduate Students Regarding CAD/CAM Technology in Tripoli Region, Libya

Ahmed Mhanni* , **Sirageddin Al-hmadi, Seham El-Sawaay**

Department of fixed prosthodontics, Faculty of dentistry, University of Tripoli, Tripoli, Libya.
Corresponding Email: *a.mhanni@uot.edu.ly*

ABSTRACT

Background and objectives: Metal-free ceramic has become increasingly popular as a result of the enormous growth in demand for cosmetic dentistry. Because of this, the majority of dentists began utilising digital technology, which allows them to work faster and produce products with attractive aesthetic and functional outcomes. The field of modern dentistry is moving closer to CAD/CAM (computer-aided design/computer-aided manufacturing) technology. The purpose of this study is to assess undergraduate students' awareness levels, with the aim of comparing the findings to change the curriculum in the future. The study's objectives were to (1) assess awareness among dental undergraduate students and (2) compare it to that of second-, third-, final-, and intern-year dental students. Methods: A cross-sectional, questionnaire-based study was carried out among dental students (second-year students, third-year students, final-year students, and interns) in the Tripoli region that extended to two dental faculties. To determine the sample size, the reference article of a comparable study conducted in India was used. There were 212 participants in this study as a total sample. The authors selected a closed-ended questionnaire. The questions were taken from other studies to clarify and fit the fixed partial denture subject. Statistical Package for Social Sciences (SPSS) version 22 was used to perform the statistical analysis. Descriptive and Chi-square tests were selected. The level of significance was set at 5%. Results: The study involved undergraduate students and interns, with the final-year undergraduate students having the highest response rate (57.1%). The majority of the students, who were in their final year, were aware of digital impressions and CAD/CAM technology. Most of the students stated that zirconium and fixed partial dentures were created using CAD/CAM technology. Prosthodontics is the area of dentistry that uses digital technology the most frequently, and CAD/CAM technology is more accurate than traditional techniques in this area. Conclusions: A large number of those who participated agreed that restorations made using CAD/CAM technology are superior to those made using conventional methods and recommended including CAD/CAM technology in the curriculum.

Keywords: Undergraduate students, CAD/CAM, interns, Tripoli

INTRODUCTION

The digitization of dentistry offers numerous advantages, including improved care quality and accurate diagnostic-based decisions [1]. In addition, it is used to improve communication between dentists, patients, and dental laboratory technicians, as well as provide outstanding quality, data archiving, and improved patient experiences [2]. However, the

adoption of digital technologies faces challenges such as a lack of knowledge and skills [3]. Many dental schools in the world are trying to incorporate digital technologies into their curricula to prepare students for the growing need for digital techniques and workflows [4,5,6,7,8].

Dentistry is constantly evolving, with digital technologies enhancing care quality and patient satisfaction [9]. Revolutionary equipment like cone beam computed tomography (CBCT), 3D scanners, and 3D printers is being introduced, transforming the field [10]. These techniques, along with advancements in dental materials, are transforming the entire field of dentistry [11,12,13]. One of these revolutionary pieces of equipment is computer-assisted design/computer-assisted manufacturing (CAD/CAM) prosthetic software and dental implant planning software [10].

CAD/CAM technology introduced in the 1970s [14,15], has become popular in dentistry for digitising and creating custom patient-specific restorations and prostheses [16]. It has been particularly useful in the production of clinical dental restorations [17], and the CEREC system in the 1980s made CAD/CAM routine in dental laboratories and clinical practises [18]. Crowns, veneers, inlays, onlays, bridges, implants, dentures, and orthodontic appliances are just some of the dental restorations that can benefit from the development of CAD/CAM. [19,20], CAD/CAM addresses three challenges: ensuring adequate strength, creating natural-looking restorations, and making tooth restoration easier, faster, and more accurate [21]. In some cases, this type of technology provides restorations for patients in one visit [19]. So far, CAD/CAM technology has become an essential part of modern dentistry [22].

CAD/CAM offers dentists less dependence on dental technicians, reduced patient visits, and cost-effective restorations [19]. However, it has limitations such as high initial costs, time and cost investment, difficulty acquiring accurate digital impressions, and fabrication errors [23,24]. In order to raise awareness of new developments in dentistry, this study intends to evaluate dental undergraduate students' knowledge and awareness of CAD-CAM technology in the Tripoli region.

METHODS

A cross-sectional study in the Tripoli region [i.e. Tripoli and Az-Zawiyah dental faculties], conducted in 2023, involved 212 dental undergraduate students (i.e., second-year students, third-year students, final-year students, and interns), using a questionnaire with 13 multiple-choice types. The majority of questions were taken from the study of Palanisamy and Hegde [21] and others were added from the studies of Shetty et al., [25] and Sharab et al., [26] in order to understand and fit the fixed partial denture subject.

The questions were gathered from these publications and analysed to identify the most relevant questions for the study's objective [21,25,26]. According to statistical analysis, the writers of these questions believed they were valid, but all the questions were sent to experts for review. A small group of five experts revised these questions to ensure that they were clear and relevant. Based on feedback from pilot testing, the pertinent questions were grouped into a questionnaire form after unrelated or similar questions were removed. The final version of the questionnaire was distributed to the target population. This questionnaire assessed awareness among dental undergraduate students regarding CAD/CAM technology. The sample size calculation was done using a reference article for a similar type of study conducted in India [21]. Questionnaires were grouped into four groups: second-year students, third-year students, final-year students, and interns. The questionnaire was designed on a Microsoft form, and the link was distributed via emails, WhatsApp, Viber, and another social media platform.

The collected data were entered in a spreadsheet (Microsoft Excel, 2019). Student names were not included in the questionnaire to ensure anonymity. The study was completed in a month (May 2023). Statistical analysis was done using descriptive statistics and Chi-square tests. Descriptive statistics include mean, standard deviation, frequency, and

proportions for quantitative variables, and inferential statistics like the Chi-square test for qualitative variables. These statistical analyses were calculated using SPSS version 22 (IBM Corp.).

RESULTS

According to the assessment of content validity, all of the questions met the criteria for inclusion in the questionnaire. The content validity was determined using the expert ratings. Each question's relevance was assessed using the content validity index (CVI). The CVI values of 0.80 or above indicated that the questions were relevant. These criteria were fulfilled by all of the questions, with CVI values ranging from 0.83 to 0.95.

Table (1) provides an illustration of the estimated subject distribution depending on the designation. 27 (12.7%), 42 (19.8%), and 121 (57.1%) of the dental students who participated in the survey were in their second, third, and final years, respectively. A total of 22 (10.4%) interns also took part in the study.

Table 1: Demographic profile of study participants

Student education level	Number of students	% Percentage
2nd year dental student	27	12.7
3rd year dental student	42	19.8
Final year dental student	121	57.1
Interns	22	10.4
Total valid	212	100

According to Tabachnick and Fidell (2001), if the missing data is in a random pattern and less than 5% of the data, it is not considered a serious problem in data analysis [27]. Table (2) demonstrated that most of the questions had missing data that was completely random, less than 5%.

Table 2: Number of replies, means, standard deviations, and missing data for each question compared to the total number of students (n = 212)

Questions	Number of reply	Mean	Standard Deviation	Missing Count	Percent
Q2	211	1.27	0.443	1	0.5
Q3	211	1.65	0.478	1	0.5
Q4	206	1.57	0.497	6	2.8
Q5	207	3.24	0.574	5	2.4
Q6	210	1.09	0.281	2	0.9
Q7	207	1.27	0.445	5	2.4
Q8	212	1.22	0.413	0	0.0
Q9	210	1.07	0.258	2	0.9
Q10	208	1.03	0.168	4	1.9
Q11	205	1.29	0.755	7	3.3
Q12	210	3.29	1.184	2	0.9
Q13	210	1.06	0.233	2	0.9

The cross-tabulation of the replies depending on the designation is estimated, as shown in Table 3. Among the participants, 15 (9.7%) interns, 91 (58.7%) final-year students, 29 (18.7%) third-year students, and 20 (12.9%) second-year students were aware of digital impressions, compared to 7 (12.5%) interns, 30 (53.6%) final-year students, 12 (21.4%) third-year students, and 7 (12.5%) second-year students who were not. The majority of undergraduate students who were final-year dental students were aware of digital impressions. When compared to 137 (65%) undergraduate students who did not see a CAD/CAM unit, only 74 (35%) undergraduate students saw a CAD/CAM unit. Furthermore, final-year students had the highest percentage of students who answered yes or no to question 3 (52.7% and 60%, respectively). Most of the undergraduate students (56.8%) were informed that there is no curriculum that contains CAD/CAM technology, while a minority of the students (43.2%) were informed there is. Most of the dental students in this sample believed that fixed partial dentures and zirconium were used with CAD/CAM technology (91.4% and 65.7%, respectively). The result also revealed that the most common dental field that utilizes digital dentistry is prosthodontics. In addition, CAD/CAM technology is

more precise than conventional methods for making a crown, bridge, or onlay. In general, there is no significant difference for all the questions between student education levels in an undergraduate programme, except question number 9. The Chi-square test for question 9 showed a statistically significant difference between the second-year, third-year, final-year dental students and interns who answered yes and no (P = 0.04).

Table 3. Cross-tabulation based on designation of the replies

Questions	Response	Designation group				Total	Chi-Square value	df	P value
		2nd year	3rd year	Final-year	Interns				
Q2: Are you aware of digital impression?	**Yes**	20	29	91	15	155	0.665	3	0.881
		12.9%	18.7%	58.7%	9.7%	73.5%			
	No	7	12	30	7	56			
		12.5%	21.4%	53.6%	12.5%	26.5%			
Q3: Have you ever seen a CAD/CAM unit?	**Yes**	12	16	39	7	74	1.854	3	0.603
		16.2%	21.6%	52.7%	9.5%	35%			
	No	15	25	82	15	137			
		10.9%	18.2%	60%	10.9%	65%			
Q4: Does your curriculum contain CAD/CAM technology in it?	**Yes**	9	16	57	7	89	3.851	3	0.278
		10.1%	18%	64%	7.9%	43.2%			
	No	18	24	60	15	117			
		15.4%	20.5%	51.3%	12.8%	56.8%			
Q5: Which among the following materials do you think can be used in CAD/CAM technology?	**Metal**	0	0	3	0	3	11.389	9	0.250
		0%	0%	100%	0%	1.4%			
	Wax	2	0	4	0	6			
		33.3%	0%	66.7%	0%	2.9%			
	Zirconium	13	29	76	18	136			
		9.6%	21.3%	55.9%	13.2%	65.7%			
	All of the above	12	12	34	4	62			
		19.4%	19.4%	54.8%	6.4 %	30%			
Q6: Can Fixed Partial Denture (FPD) be done using CAD/CAM technology?	**Yes**	22	40	110	20	192	4.349	3	0.226
		11.5%	20.8%	57.3%	10.4%	91.4%			
	No	5	2	9	2	18			
		27.8%	11.1%	50%	11.1%	8.6%			
Q7: Can post and core be done using	**Yes**	15	32	88	16	151	5.306	3	0.151
		9.9%	21.2%	58.3%	10.6%	72.9%			

CAD/CAM technology?	No	12	8	30	6	56			
		21.4%	14.3%	53.6%	10.7%	27.1%			
Q8: Are you aware of three-dimensional (3D) printing technology?	Yes	21	32	97	16	166	0.764	3	0.858
		12.7%	19.3%	58.4%	9.6%	78.3%			
	No	6	10	24	6	46			
		13%	21.8%	52.2%	13%	21.7%			
Q9: Do you think if CAD/CAM technology is more precise than conventional procedures?	Yes	22	38	113	22	195	8.111	3	0.044*
		11.3%	19.5%	57.9%	11.3%	92.9%			
	No	5	4	6	0	15			
		33.3%	26.7%	40%	0%	7.1%			
Q10: Which will produce faster restorations (Crown, Bridge, Onlay): CAD/CAM technology or conventional method?	CAD/CAM	27	40	114	21	202	1.155	3	0.764
		13.4%	19.8%	56.4%	10.4%	97.1%			
	Conventional method	0	1	4	1	6			
		0%	16.7%	66.6%	16.7%	2.9%			
Q11: What does CAD/CAM stand for?	Computer-aided design and computer-aided manufacturing	22	32	98	21	173	6.177	9	0.772
		12.7%	18.5%	56.7%	12.1%	84.4%			
	Computer-aided dentistry and computer-aided medicine	1	4	8	0	13			
		7.7%	30.8%	61.5%	0%	6.3%			
	Computer-analyzed dentistry and computer-analyzed medicine	1	3	5	1	10			
		10%	30%	50%	10%	4.9%			
	Computer-adapted dentistry and computer-adapted medicine	2	3	4	0	9			
		22.2%	33.3%	44.5%	0%	4.4%			
Q12: Which the most dental field do you think utilizes digital dentistry?	General Dentistry	7	6	20	2	35	9.053	9	0.432
		20%	17.1%	57.2%	5.7%	16.7%			
	Oral and Maxillofacial Surgery	3	7	9	1	20			
		15%	35%	45%	5%	9.5%			
	Periodontics	1	2	2	0	5			
		20%	40%	40%	0%	2.4%			

	Prosthodontics	16	27	89	18	150			
		10.7%	18%	59.3%	12%	71.4%			
Q13: Do you see yourself using digital dentistry in your future career?	**Yes**	26	42	110	20	198	3.969	3	0.265
		13.1%	21.2%	55.6%	10.1%	94.3%			
	No	1	0	9	2	12			
		8.3%	0%	75%	16.7%	5.7%			

*Significant

Table 4 shows a strong association between certain questions (p ≤0.05), for instance, indicating students' familiarity with CAD/CAM and its functions.

Table 4: The significant association between questions

Questions	Value	df	Asymptotic Significance (2-sided)
Q2 & Q3	20.125	1	0.000
Q2 & Q4	4.622	1	0.032
Q6 & Q7	3.697	1	0.054
Q3 & Q8	10.182	1	0.001
Q9 & Q10	6.918	1	0.009
Q6 & Q10	4.688	1	0.030
Q11 & Q12	29.153	9	0.001

DISSCUSION

Dentistry has evolved from crude restorations made of wires and wood to the digital world of digital dentistry. CAD/CAM technology has become popular over the past three decades, resulting in the precise and accurate fabrication of prostheses with fewer errors in the patient's mouth. This has overcome the disadvantages of conventional methods, such as quality, labour, and duration [17]. A questionnaire survey was conducted to assess the basic knowledge of CAD/CAM technology among undergraduate students and interns. It was also found that 90.3% of the dental students and 9.7% of the interns were aware of digital impressions. According to another survey in Saudi Arabia, 85.9% of interns and 95.1% of students are aware of digital impressions, which is in line with prior research in central India that revealed 68% and 94.67% of participants were aware of this concept [28].

According to the present study, the majority of the students have not seen a CAD/CAM unit. This was controversial with Palanisamy et al. who explained that interns who have a higher academic ranking and exposure to newer technology are superior to other undergraduate students [21]. This result was also supported by Shetty et al. 72.9% of interns were exposed to CAD/CAM technology in Makkah, Saudi Arabia [25]. However, research by Todkar et al. found that 67.1% of dental students were aware of the use of CAD/CAM technology in dentistry, which was only marginally higher than the survey by Maltar et al. in 2018 (64.4%) [29,30].

In the current study, 12.8% of interns and 87.2% of dental students (i.e., 51.3% of final-year students, 20.5% of third-year students, and 15.4% of second-year students) responded negatively when asked if CAD/CAM technology is used in their curriculum, while in the Makkah region, 24.4% of interns and 65.3% of students responded positively [25]. According to the study by Palanisamy et al. in 2019, 18.3% of undergraduate students at the A. B. Shetty Memorial Institute of Dental Science in India demonstrated that their curriculum incorporated a CAD/CAM system. In addition, third-year and fourth-year dental students in the same study reported using CAD/CAM systems in their coursework in 42% and 53.20% of cases, respectively [21]. Another survey conducted among dental undergraduate students in India from December 2020 to May 2021 found that many students were unaware of the advancements in CAD/CAM technology. Among the students surveyed, 65% had CAD/CAM technology included in their curriculum. The study suggests that students should be made

aware of CAD/CAM technology academically as well as practically, as the future of dentistry will be digitally driven [28].

Dental students in the Tripoli region mostly believed zirconium was the only material used in CAD/CAM technology, with 30% suggesting metal, wax, and zirconium could also be used. According to a number of additional studies, CAD/CAM technology is used in a variety of restorations, including multi-unit fixed partial dentures (FPD), onlays, inlays, crowns, veneers, and bone regeneration. Additionally, it is used in guided implant surgery and removable dentures [9, 31]. Therefore, the result of the present study reported that CAD/CAM was found to be more effective in fixed partial denture restorations and post-crowns (91.4% and 72.9%, respectively). According to Palanisamy et al.'s research, more than 70% of students believed that CAD/CAM made crowns are superior to traditionally constructed crowns in every way [21]. This finding confirmed the result of the present study. The sample as a whole agreed with the prior statement by 97.1%. In contrast, a study conducted in 2021 by Nassani et al. revealed that 34.3% of respondents thought CAD/CAM fabricated crowns were equal to conventional procedures, and 28.1% thought they were superior [9]. The majority of survey respondents in the study (84.4%) correctly defined the word "CAD/CAM." However, 71.4% of respondents stated that prosthodontics is the area of dentistry that uses CAD/CAM technology the most. One possible reason for this is that the students' clinical experiences may have influenced their understanding of concepts. The inadequate understanding of the dental specialty at this educational level may also be a contributing factor [26]. In addition, 94.3% of students anticipate using digital dentistry in the future, indicating interest in digital technology, especially from a "digitally savvy" generation. The remaining 5.7% may not have a clear understanding of the practise conditions due to lack of knowledge, mistrust, expensive equipment, and proper training requirements [5,26].

CAD/CAM technology has revolutionised the field of dentistry and become an essential component of modern dental practise. With its ability to produce accurate, high-quality restorations efficiently and effectively, CAD/CAM technology has drastically reduced the time and cost associated with traditional dental procedures. As such, it is important for undergraduate dental students to gain a comprehensive understanding of this technology and its applications to provide the highest level of patient care [32]. The incorporation of CAD/CAM technology into dental curricula will prepare the next generation of dentists to excel in this rapidly advancing field and improve patient outcomes [32,33]. By examining dental students' understanding of CAD/CAM technology, the result of this study will help dental educators predict future movements and enhance their teaching strategies. However, study data is limited by demography and subjectivity. Dental students should be involved in a thorough survey to compare the information acquired and identify areas for development.

CONCLUSION

The results of the study revealed that while the majority of students who responded to the questionnaire had a sufficient understanding of CAD/CAM technology, they had never seen it in reality. Furthermore, it was not one of the main topics addressed in the curriculum. In order to improve students' knowledge and clinical practise, the curriculum should be regularly updated to reflect the most recent developments. The knowledge that today's students receive will be reflected in their practise as tomorrow's dentists. Therefore, to prepare them for the future of dentistry, undergraduate students should be made academically and practically aware of CAD/CAM technology.

Limitation of the study and recommendation

The study had some limitations, such as a small sample size of 212 dental students from the Tripoli region, an uneven distribution at each educational level, and the omission of the names of the faculties from the electronic version of the questionnaire that

was given. In order to better understand the effects of CAD/CAM technology on dental students' knowledge and awareness, more research is required to analyse dental students' knowledge and awareness of the use of CAD/CAM technology in prosthodontics by increasing the study's coverage.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

REFERENCES

1. Tallarico M. Computerization and digital workflow in medicine: Focus on digital dentistry. Materials. 2020 May 8;13(9):2172.

2. Delrose DC, Steinberg RW. The clinical significance of the digital patient record. The Journal of the American Dental Association. 2000 Jun;131:57S-60S.

3. Matthews DC, McNeil K, Brillant M, Tax C, Maillet P, McCulloch CA, Glogauer M. Factors influencing adoption of new technologies into dental practice: a qualitative study. JDR Clinical & Translational Research. 2016 Apr;1(1):77-85.

4. Gratton DG, Kwon SR, Blanchette D, Aquilino SA. Impact of digital tooth preparation evaluation technology on preclinical dental students' technical and self-evaluation skills. Journal of dental education. 2016 Jan;80(1):91-9.

5. Schlenz MA, Michel K, Wegner K, Schmidt A, Rehmann P, Wöstmann B. Undergraduate dental students' perspective on the implementation of digital dentistry in the preclinical curriculum: a questionnaire survey. BMC oral health. 2020 Dec;20:1-0.

6. Jurado CA, Tsujimoto A, Punj A, Aida N, Miyazaki M, Watanabe H. Successful development and implementation of a digital dentistry curriculum at a US dental school. Journal of oral science. 2021;63(4):358-60.

7. Ishida Y, Kuwajima Y, Kobayashi T, Yonezawa Y, Asack D, Nagai M, Kondo H, Ishikawa-Nagai S, Da Silva J, Lee SJ. Current implementation of digital dentistry for removable prosthodontics in US Dental Schools. International Journal of Dentistry. 2022 Apr 15;2022.

8. Petrie CS, Hayes K, Scott JM, Walker MP. Effectiveness of digital impressions in a predoctoral clinical curriculum. International Journal of Computerized Dentistry. 2022 Apr 1;25(2).

9. Nassani MZ, Ibraheem S, Shamsy E, Darwish M, Faden A, Kujan O. A Survey of Dentists' Perception of Chair-Side CAD/CAM Technology. Healthcare. 2021 Jan 13;9(1):68.

10. Jacobs R, Salmon B, Codari M, Hassan B, Bornstein MM. Cone beam computed tomography in implant dentistry: recommendations for clinical use. BMC oral health. 2018 Dec;18(1):1-6.

11. Spector L. Computer-aided dental implant planning. Dental Clinics of North America. 2008 Oct 1;52(4):761-75.

12. Mangano F, Gandolfi A, Luongo G, Logozzo S. Intraoral scanners in dentistry: a review of the current literature. BMC oral health. 2017 Dec;17(1):1-1.

13. Bayne SC, Ferracane JL, Marshall GW, Marshall SJ, Van Noort R. The evolution of dental materials over the past century: silver and gold to tooth color and beyond. Journal of dental research. 2019 Mar;98(3):257-65.

14. Al Essa HA. CAD/CAM in prosthodontics: A gate to the future. International Journal of Applied Dental Sciences. 2019;5(3):394-7.

15. Chatham C, Spencer MH, Wood DJ, Johnson A. The introduction of digital dental technology into BDS curricula. British dental journal. 2014 Dec 5;217(11):639-42.

16. Goodacre CJ, Garbacea A, Naylor WP, Daher T, Marchack CB, Lowry J. CAD/CAM fabricated complete dentures: concepts and clinical methods of obtaining required morphological data. The Journal of prosthetic dentistry. 2012 Jan 1;107(1):34-46.

17. Jain R, Takkar R, Jain G, Takkar R, Deora N, Jain R. CAD-CAM the future of digital dentistry: a review. Annals of Prosthodontics & Restorative Dentistry. 2016 Apr;2(2):33-36.

18. 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. Dental materials journal. 2009;28(1):44-56.

19. Davidowitz G, Kotick PG. The use of CAD/CAM in dentistry. Dental Clinics. 2011 Jul 1;55(3):559-70.

20. Rekow D. Computer-aided design and manufacturing in dentistry: a review of the state of the art. The Journal of prosthetic dentistry. 1987 Oct 1;58(4):512-6.

21. Palanisamy SV, Hegde C. Awareness among dental undergraduate students regarding CAD/CAM technology—A survey report. Journal of Health and Allied Sciences NU. 2019 Apr;9(02):57-63.

22. Li RW, Chow TW, Matinlinna JP. Ceramic dental biomaterials and CAD/CAM technology: state of the art. Journal of prosthodontic research. 2014 Oct 1;58(4):208-16.

23. Aslam, K., & Nadim, R. (2015). A review on cad cam in dentistry. Journal of the Pakistan Dental Association 2015;24(03), 112

24. Samra AP, Morais E, Mazur RF, Vieira SR, Rached RN. CAD/CAM in dentistry–a critical review. Revista Odonto Ciência. 2016 Dec;31(3):140-4.

25. Shetty K, A Balkhyoor JA, Hamdi SS, Aloufi GT, Amer AN. Awareness Among the Undergraduate Dental Students Regarding Computer Aided Design and Computer Aided Manufacturing Technology in Various Universities at Makkah Region, Saudi Arabia- A Questionnaire-Based Study. International Journal of Life Science and Pharma Research. 2022 Aug; 12(5):L103–L109. Available from: http://dx.doi.org/10.22376/ijpbs/lpr.2022.12.5.l103-109

26. Sharab L, Adel M, Abualsoud R, Hall B, Albaree S, de Leeuw R, Kutkut A. Perception, awareness, and attitude toward digital dentistry among pre-dental students: An observational survey. Bulletin of the National Research Centre. 2022 Dec;46(1):1-7.

27. Tabachnick BG, Fidell LS, Ullman JB. Using multivariate statistics. Boston, MA: Pearson; 2013:54-62.

28. Gade, J, Jaiswal K, Agrawal M, Agarkar A, Ingole A, Dandekar S. Knowledge and awareness amongst dental undergraduate students regarding CAD-CAM technology in central India: A cross sectional survey. Journal of Research in Medical and Dental Science, 2021 Oct;9(10):8-11.

29. Todkar M, Nagarale R, Sayyad T, Fatima A, Siddiqui FJS, & Katanghar S. Awareness, attitude and knowledge of computer aided design/computer aided manufacturing (cad/cam) among dental professionals. International Journal of Applied Dental Sciences 2022;8(1): 376-381. It is available at: https://www.oraljournal.com/pdf/2022/vol8issue1/PartF/8-1-13-960.pdf

30. Maltar M, Miloš L, Milardović S, Kovačić I, Peršić S, Juroš I, Kranjčić J. Attitudes of the Students from the School of Dental Medicine in Zagreb towards CAD/CAM. Acta stomatologica Croatica: International journal of oral sciences and dental medicine. 2018 Dec Dec;52(4):322-329.

31. Sriram S, Shankari V, Chacko Y. Computer aided designing/computer aided manufacturing in dentistry (CAD/CAM)–A Review. International Journal of Current Research and Review. 2018 Oct;10(20):20-24.

32. Alhamed FJ, Neiva GF, Bak SY, Karl E, Inglehart MR. Pre‐doctoral dental students' computer‐aided design/computer‐aided manufacturing‐related education, knowledge, attitudes and behavior: A national survey. Journal of Dental Education. 2023 Apr;87(4):562-71.

33. Callan RS, Palladino CL, Furness AR, Bundy EL, Ange BL. Effectiveness and feasibility of utilizing E4D technology as a teaching tool in a preclinical dental education environment. Journal of dental education. 2014 Oct;78(10):1416-23.