



A RESEARCH ARTICLE



Knowledge, Awareness, and Attitudes Toward 3D Printing Materials in Prosthodontics Among Dental Students: A Multi-Center Cross-Sectional Study in Libya

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Abstract

Three-dimensional (3D) printing has become an essential component of modern prosthodontics, offering improved accuracy, efficiency, and customization. However, its effective clinical implementation depends on adequate knowledge of printing materials among dental students. This study aimed to assess the knowledge, awareness, and attitudes of dental students regarding 3D printing materials in prosthodontics in Libya. A multi-center descriptive cross-sectional study was conducted among undergraduate dental students and interns from public and private universities in Libya between March and April 2026. A total of 300 questionnaires were distributed electronically, and 201 completed responses were included in the final analysis (response rate: 67.0%). Data were analyzed using SPSS version 23. Descriptive statistics and Chi-square tests were applied, with statistical significance set at $p < 0.05$. Participants demonstrated moderate levels of knowledge and awareness regarding 3D printing in dentistry. While 78.1% recognized its applications in prosthodontics, more than half were unable to identify specific materials used. Resin and acrylic-based materials were the most commonly recognized. Nearly half of the participants expressed uncertainty regarding material safety and mechanical properties. Despite these gaps, the majority (93%) showed a positive attitude and interest in learning more about digital dentistry. Clinical level and attendance of educational courses were significantly associated with higher knowledge and awareness ($p < 0.05$). The findings highlight gaps in material-specific understanding and emphasize the need for structured integration of digital dentistry education into undergraduate curricula.

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1. Introduction

Recent advances in digital dentistry have significantly transformed clinical practice, particularly in prosthodontics. Among these developments, three-dimensional (3D) printing, also known as additive manufacturing, has emerged as a key technology enabling the fabrication of dental structures through a precise layer-by-layer process. This technology provides high levels of customization and has been widely applied in the production of denture bases, temporary restorations, surgical guides, and diagnostic models [1–4].

The effectiveness of 3D printing in prosthodontics depends heavily on material selection. Various materials such as photopolymer resins, acrylic-based materials, metal alloys, and ceramic composites have been developed to meet the mechanical, physical, and aesthetic requirements of dental applications. The choice of material directly influences durability, dimensional accuracy, biocompatibility, and clinical performance [2,4,5].

Despite global progress in digital dentistry, variations in knowledge and awareness among dental students remain evident. Previous studies have reported moderate awareness levels but persistent deficiencies in understanding material properties and clinical applications. Although students generally recognize the benefits of digital dentistry, gaps in material-specific knowledge continue to exist across different populations [6–10].

As digital technologies become increasingly integrated into routine dental practice, dental education programs are expected to provide students with both theoretical knowledge and practical exposure to digital workflows, including computer-aided design/computer-aided manufacturing (CAD/CAM) systems and additive manufacturing technologies. Early exposure to digital dentistry may enhance students' clinical preparedness and facilitate the adoption of emerging treatment modalities in future professional practice [11–14].

Based on the growing importance of digital dentistry and the limited available evidence from Libya, it was hypothesized that dental students would demonstrate moderate levels of knowledge and awareness regarding 3D printing materials in prosthodontics. It was further hypothesized that students with greater clinical exposure and previous educational experience in digital dentistry would exhibit significantly higher levels of knowledge and awareness than their counterparts [6,9,10,11].

In Libya, no previous multi-center study has assessed dental students' knowledge of 3D printing materials across both public and private institutions. Therefore, this study aimed to evaluate the knowledge, awareness, and attitudes of dental students toward 3D printing materials in prosthodontics in Libya.

2. Materials and Methods

2.1. Study Design and Setting

This multi-center descriptive cross-sectional study was conducted across public and private dental schools in Libya, including Benghazi, Tripoli, and Tobruk, between March and April 2026.

2.2. Study Population and Sampling

The study included undergraduate dental students (2nd–5th year) and dental interns. A convenience sampling method was used. A total of 300 students were invited, and 201 completed the questionnaire and were included in the final analysis.

Participants were grouped into:

- *Preclinical: 2nd and 3rd year students*
- *Clinical: 4th and 5th year students and interns*

The questionnaire was distributed electronically through official student communication channels in participating institutions located in Benghazi, Tripoli, and Tobruk. To minimize duplicate submissions, the survey platform permitted only one response from each participant. Incomplete questionnaires were excluded from the final analysis. Convenience sampling was adopted due to the geographical distribution of participants across multiple institutions and the logistical challenges associated with recruiting students from different universities throughout Libya.

2.3. Data Collection Tool

Data were collected using a structured self-administered questionnaire developed after reviewing relevant literature. The questionnaire included four sections: demographic data, knowledge of 3D printing, awareness of materials, and attitudes toward digital dentistry.

2.4. Validity and Pilot Study

Content validity was assessed by experts in prosthodontics and dental education. A pilot study involving 20 students (not included in the final sample) was conducted to test clarity and feasibility, and minor modifications were made accordingly.

2.5. Data Collection Procedure

Data were collected electronically between March and April 2026. Participation was voluntary and anonymous.

2.6. Ethical Approval

Ethical approval was obtained from the Faculty of Dentistry, University of Benghazi, Libya (Approval No. 400). Informed consent was obtained from all participants, and confidentiality was ensured.

2.7. Statistical Analysis

Data were analyzed using SPSS version 23. Descriptive statistics and Chi-square tests were used. A p -value < 0.05 was considered statistically significant. Knowledge and awareness scores were categorized into low, moderate, and high based on tertile distribution.

3. Results

3.1. Demographic Characteristics

A total of 201 students participated. Females represented 66.7% and males 33.3%. Most participants were second-year students (46.3%). More than half (56.2%) were from governmental universities. Only 21.4% had attended lectures or courses related to 3D printing (Table 1).

Table 1. Demographic characteristics of the study participants.

Characteristics	No.	(%)
Gender		
Male	67	33.3%
Female	134	66.7%
Academic level		
2nd year	93	46.3%
3rd year	46	22.9%
4th year	36	17.9%
5th year	17	8.5%
Intern	9	4.5%
Type of Institution		
Private	88	43.8%
Governmental	113	56.2%
Have you ever attended a lecture or course about 3D printing in dentistry?		
No	158	78.6%
Yes	43	21.4%

3.2. Knowledge of 3D Printing in Dentistry

54.2% were familiar with 3D printing in dentistry, and 78.1% recognized its prosthodontic applications. Denture bases were the most commonly identified application (56.2%). However, 54.7% could not identify specific materials. Resin and acrylic-based materials were the most recognized (Table 2).

Table 2. Knowledge of dental students regarding 3D printing applications in prosthodontics

Characteristics	No.	(%)
Are you familiar with the concept of 3D printing in dentistry?		
No	92	45.8%
Yes	109	54.2%
Do you know that 3D printing can be used in prosthodontics?		
No	44	21.9%
Yes	157	78.1%
Which of the following prosthodontic applications can be produced using 3D printing?		
Denture bases	113	56.2%
Surgical guides	40	19.9%
Temporary crowns	94	46.8%
Dental models	90	44.8%
I do not know	63	31.3%
Are you aware that different materials are used in dental 3D printing?		
No	87	43.3%
Yes	114	56.7%
Which of the following materials are used in dental 3D printing?		
Resin	53	26.4%
Acrylic-based materials	52	25.9%
Metal alloys	36	17.9%
Ceramic materials	41	20.4%
I do not know	110	54.7%

3.3. Awareness of 3D Printing Materials

47.8% believed 3D printing materials are safe for intraoral use, while a similar proportion were uncertain. Only 46.8% were aware of post-processing requirements. Overall, 63.2% believed 3D printing may replace conventional methods in the future (Table 3).

Table 3. Awareness of dental students regarding 3D printing materials used in prosthodontics.

Characteristics	No.	(%)
Do you think 3D printing materials are safe for intraoral use?		
No	12	6.0%
Yes	96	47.8%
Not sure	93	46.3%
Do you believe 3D printed prosthetic materials have adequate strength for dental use?		
No	21	10.4%
Yes	96	47.8%
Not sure	84	41.8%
Are you aware that some 3D printed materials require post-processing (washing and curing)?		
No	31	15.4%
Yes	94	46.8%
Not sure	76	37.8%
Do you think 3D printed prostheses may replace conventional methods in the future?		
No	15	7.5%
Yes	127	63.2%
Not sure	59	29.4%

3.4. Attitudes Toward 3D Printing

A high proportion (93%) supported the inclusion of 3D printing education in curricula and expressed interest in learning more. More than half believed 3D printing will become common in Libya (Table 4).

Table 4. Attitudes of dental students toward 3D printing and digital dentistry.

Characteristics	No.	(%)
Do you think dental students should receive more education about 3D printing materials?		
No	14	7.0%
Yes	187	93.0%
Are you interested in learning more about digital dentistry and 3D printing?		
No	14	7.0%
Yes	187	93.0%
Do you think 3D printing will become common in dental practice in Libya?		
No	21	10.4%
Yes	114	56.7%
Not sure	66	32.8%

3.5. Levels of Knowledge and Awareness

Moderate knowledge was observed in 48.8% of participants, while 36.3% had low knowledge. Similar trends were observed for awareness levels (Table 5).

Table 5. Distribution of participants according to levels of knowledge and awareness.

Characteristics	No.	(%)
Levels of Knowledge		
low	73	36.3%
Moderate	98	48.8%
High	30	14.9%
Levels of Awareness		
low	69	34.3%
Moderate	100	49.8%
High	32	15.9%

3.6. Association Between Variables

Clinical students showed significantly higher knowledge and awareness than preclinical students ($p < 0.05$). Attendance of educational courses was also significantly associated with higher knowledge and awareness ($p < 0.001$) (Table 6).

Table 6. Association between academic level and levels of knowledge and awareness among participants.

Characteristics	Academic level		p-value
	Preclinical	clinical	
	Levels of Knowledge		
low	59 (29.4%)	14 (7.0%)	0.003
Moderate	66 (32.8%)	32 (15.9%)	
High	14 (7.0%)	16 (8.0%)	
	Levels of Awareness		
low	60 (29.9%)	9 (4.5%)	$p < 0.001$
Moderate	55 (27.4%)	45 (22.4%)	
High	24 (11.9%)	8 (4.0%)	
	Have you ever attended a lecture or course about 3D printing in dentistry?		
	No	Yes	
	Levels of Knowledge		
low	67 (33.3%)	6 (3.0%)	0.001
Moderate	73 (36.3%)	25 (12.4%)	
High	18 (9.0%)	12 (6.0%)	
	Levels of Awareness		
low	65 (32.0%)	4 (2.0%)	$p < 0.001$
Moderate	75 (37.3%)	25 (12.4%)	
High	18 (9.0%)	43 (21.4%)	

4. Discussion

The present multicenter study evaluated the knowledge, awareness, and attitudes of dental students in Libya regarding 3D printing materials in prosthodontics. The findings revealed that although general familiarity with 3D printing is relatively acceptable, there is a substantial gap in material-specific knowledge and understanding of clinical applications.

Overall, participants demonstrated moderate levels of knowledge and awareness, which is consistent with findings reported in previous studies conducted in Saudi Arabia, Egypt, and India [6–10]. This suggests that while digital dentistry concepts are being introduced in undergraduate curricula, their integration remains largely theoretical with limited practical application and material-focused training.

A key finding of this study is the insufficient knowledge regarding 3D printing materials, as more than half of participants were unable to identify specific materials used. This deficiency is clinically significant, as material selection directly affects prosthesis performance, including mechanical strength, dimensional accuracy, durability, and biocompatibility [2,4,5].

Furthermore, a considerable proportion of participants expressed uncertainty regarding the safety and mechanical properties of 3D printing materials. This reflects limited exposure to hands-on training and insufficient integration of clinical workflows in digital dentistry education.

The study also demonstrated that clinical-level students exhibited significantly higher knowledge and awareness compared with preclinical students. This finding is expected, as clinical exposure enhances understanding of prosthodontic materials and digital applications.

The significant association between academic level and knowledge further supports the importance of educational progression in developing competency in digital dentistry. Students who had advanced into clinical training demonstrated greater familiarity with digital technologies and material-related concepts than those in earlier academic years.

Similarly, attendance of educational courses was significantly associated with higher knowledge and awareness, indicating the positive impact of structured educational interventions.

Students who had participated in educational activities demonstrated better outcomes than those without previous exposure. This finding is consistent with recommendations advocating the incorporation of digital dentistry and additive manufacturing technologies into undergraduate curricula through lectures, workshops, simulation exercises, and laboratory-based training [11–14].

Despite these gaps, students demonstrated highly positive attitudes toward 3D printing and digital dentistry, with strong interest in further learning and curriculum inclusion.

From a broader perspective, these findings highlight a gap in undergraduate dental education in Libya, particularly in digital material science and applied training. Although global advancements in additive manufacturing continue to reshape prosthodontic practice, educational implementation remains inconsistent across institutions.

The inclusion of participants from different Libyan cities and from both public and private universities enhances the representativeness of the study. Nevertheless, potential differences in institutional resources, curriculum structure, availability of digital technologies, and opportunities for practical training were not specifically investigated. Future multicenter studies should explore these factors to identify educational disparities and guide curriculum development at the national level.

5. Limitations

Several limitations should be considered when interpreting the findings of this study. First, the cross-sectional design does not permit the establishment of causal relationships between educational exposure and knowledge levels. Second, the use of convenience sampling may have introduced selection bias and may limit the generalizability of the findings to all dental students in Libya. Third, the unequal representation of academic levels, particularly the predominance of second-year students and the relatively small proportion of interns, may have influenced the overall estimates of knowledge and awareness. Fourth, the questionnaire relied on self-reported responses, which may reflect perceived awareness rather than objectively measured knowledge. Finally, although the study included participants from multiple cities and from both public and private institutions, subgroup analyses according to university or geographical location were beyond the scope of the present study.

6. Conclusion and Recommendations

6.1. Conclusion

This multicenter study demonstrated that Libyan dental students possess moderate levels of knowledge and awareness regarding 3D printing materials used in prosthodontics, despite exhibiting highly positive attitudes toward digital dentistry. Significant deficiencies were identified in material-specific knowledge, understanding of material properties, and awareness of clinical applications. Clinical exposure and participation in educational activities were significantly associated with higher knowledge and awareness levels. However, interpretation of the findings should consider the potential influence of convenience sampling and the unequal academic distribution of participants. The integration of structured digital dentistry education, supported by practical training and material-focused instruction, may help bridge current knowledge gaps and improve future clinical preparedness.

6.2. Recommendations

- Integration of digital dentistry and 3D printing into undergraduate curricula
- Increased emphasis on material science related to additive manufacturing
- Implementation of hands-on training and simulation-based learning
- Organization of workshops and continuing education programs
- Strengthening collaboration with digital dental laboratories
- Further multicenter longitudinal studies in Libya

Conflicts of interest

There are no conflicts of interest.

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المعرفة والوعي والاتجاهات نحو مواد الطباعة ثلاثية الأبعاد في طب الأسنان التعويضي لدى طلاب طب الأسنان: دراسة مقطعية متعددة المراكز في ليبيا

الملخص

أصبحت الطباعة ثلاثية الأبعاد عنصرًا أساسيًا في طب الأسنان التعويضي الحديث، لما توفره من دقة وكفاءة وتخصيص أفضل. ومع ذلك، فإن تطبيقها السريري الفعال يعتمد على معرفة طلاب طب الأسنان الكافية بمواد الطباعة. هدفت هذه الدراسة إلى تقييم معرفة طلاب طب الأسنان، ووعيهم، واتجاهاتهم نحو مواد الطباعة ثلاثية الأبعاد في طب الأسنان التعويضي في ليبيا. أجريت دراسة وصفية مقطعية متعددة المراكز بين طلاب طب الأسنان الجامعيين والمتدربين من الجامعات الحكومية والخاصة في ليبيا خلال الفترة من مارس إلى أبريل 2026. وُزِعَ ما مجموعه 300 استبيان إلكترونيًا، وشمل التحليل النهائي 201 استجابة مكتملة (معدل الاستجابة: 67.0%). حُلَّت البيانات باستخدام برنامج SPSS الإصدار 23. طُبِّقَت الإحصاءات الوصفية واختبارات مربع كاي، مع تحديد مستوى الدلالة الإحصائية عند قيمة $p < 0.05$. أظهر المشاركون مستويات متوسطة من المعرفة والوعي بتقنية الطباعة ثلاثية الأبعاد في طب الأسنان. فبينما أدرك 78.1% منهم تطبيقاتها في طب الأسنان التعويضي، لم يتمكن أكثر من نصفهم من تحديد المواد المستخدمة تحديدًا. وكانت المواد الراتنجية والأكريليكية هي الأكثر شيوعًا. وأعرب ما يقرب من نصف المشاركين عن عدم يقينهم بشأن سلامة المواد وخصائصها الميكانيكية. وعلى الرغم من هذه الثغرات، أبدى معظمهم (93%) موقفًا إيجابيًا واهتمامًا بمعرفة المزيد عن طب الأسنان الرقمي. وارتبط المستوى السريري وحضور الدورات التعليمية ارتباطًا وثيقًا بارتفاع مستوى المعرفة والوعي ($p < 0.05$). تُسلط هذه النتائج الضوء على ثغرات في فهم المواد، وتؤكد على ضرورة دمج تعليم طب الأسنان الرقمي بشكل منهجي في مناهج البكالوريوس.

الكلمات المفتاحية: الطباعة ثلاثية الأبعاد، طب الأسنان التعويضي، طلاب طب الأسنان، طب الأسنان الرقمي، التصنيع الإضافي