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ORIGINAL ARTICLE

Assessment of Knowledge and Practice of 3D printing amongst the dentists of Lahore

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ABSTRACT

Background: The development of digital technologies in dentistry resulted in the introduction of 3 D printing. The faster manufacturing rate and patient-friendly approach of this technology have revolutionized dentistry.
Aim: The aim of this study was the assessment of knowledge and practices of 3 D printing technology in Lahore.
Methods: The cross-sectional study was conducted in private teaching institutes and private clinics of Lahore. A well structuedquestionnaie consisting of 20 questions was randomly distributed in 141 particapants. Data was eanalysed by SPSS vesion 23. The results were presented in percentages.
Results: The majority 108(78%) of the participants did not use 3D printing technology during the past five years,, and the 86(61%) used it once a year, during their clinical practice. Most of the respondents 81(57.4%) were aware of Stereolithographic technique of 3 D printing. Temporary crowns 30(21.3%) were fabricated by 3 D printing. PMMA 63(44.7%) and PEEK 54(38.3%) were the most commonly used polymers, while Zirconia126(89.4%) and Titanium alloys117(83%) were mostly used for the fabrication of 3D printed dental prosthesis.
Conclusion: Majority of the particiapants were not aware of 3 D printing technique and materials used for the fabrication of 3 D printes appliances. Most participants did not use 3D printing in their clinical practices. There was no current information about 3D printing technology and techniques in the undergraduate syllabus and courses of teaching.
Practical implications: The future of dentistry involves using newer technology and keeping abreast with upcoming techniques for delivering better and more efficient healthcare. Most of these technologies are already available in market, but putting them to good use and familiarizing with them is the need of hour fo Pakistani dentist.
Keywords: 3D printing, dental prosthesis, rapid protoyping, polymethyl meth acrylate (PMMA), Stereolithography Apparatus

INTRODUCTION

Three-dimensional (3D) printing is an additive manufacturing method that produces three-dimensional structures by addingmaterial in layers. This is a relatively fast process and is referred to as rapid prototyping. It has gained rapid popularity in dentistry due to its accuracy, efficiency, and precision. Metals, polymers, and ceramics are most commonly processed at the moment[1].

The type of 3D printing technology selected mainly depends on the surface quality or accuracy requirements of a specific material and the device being manufactured[2,3]. Compared to traditional fabrication methods, 3D-printed artificial teeth, indirect artificial restorations,and treatment planning have become more readily available due to rapid production with high precision.[4] Moreover, 3D printing designed for dental applications can now help dentists provide patients with more personalized service at a substantially lower cost and has simplified the complex workflow involved in producing dental appliances[5].

A wide variety of systems are used for 3D printing in dentistry. The most commonly used techniques are Fused deposition modeling (FDM),StereolithographyApparatus(SLA), Selective Laser Melting (SLM), and Selective Laser Sintering (SLS)[6].

Different types of polymers, for instance, Poly-Lactic Acid (PLA), Acrylonitrile butadiene styrene (ABS),Poly methyl methacrylate (PMMA),and Polyether ether ketone (PEEK), can be used for prototyping by the FDM technique. SLA involves the use of an Ultraviolet light source and photo-curable polymersto fabricate different prostheses[7,8]. The SLS technique employs powdered sintered polymeric materials and a high energy laser source. SLM system is used for metals and alloys-based fabrication[9,10].

The benefits of different 3D printing techniques include good mechanical properties, increased machinability of materials, low cost, durability and fast printing time, acceptable print resolution, and process automation[11]. The disadvantages include the need for support structures and thermal shrinkage of filaments[12]. The unavailability of appropriate materialsand high production cost are hindrances[13].

In Pakistan, 3D printing facilities for dental treatment are available in most major cities, such as Karachi, Lahore, Faisalabad, Islamabad, etc. Still, it should be more popular because of limited materials and machineryandthe need forapplication information. Design inaccuracies and processing defects may be some of the limiting factors as well as restricted build-up size,high operatory cost, and government restrictions on the import of certain 3D printers also limit its use[14].

This study assessed Lahore-based dentists' knowledge and practices about 3D printing and the available materials and equipment used for 3D-printed dental appliances.

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MATERIALS AND METHODS

A cros sectional study was conducted in four different Dental teaching hospitals and private clinics in Lahore after IRB permission. A total (n=141) participants (House officers, demonstrators, postgraduate residents, and private practitioners) were included in the study. A pilot study was run on thirty participants to test the validity and the questions were modified. The informed consent was taken in the beginning of the questionnaire. An online questionnaire, in the form of google docs consisting of twenty questions was developed and distributed through what's app groups, emails and google forms. It consisted of three sections. Section one contained demographic data. The second section was composed of ten questions related to the knowledge of 3 D printing and third section included seven questions based on the practices of 3D printing. SPSS Version 23.0 was used for data entry and statistical analysis. Data waspresented in percentages and frequencies.

RESULTS

The majority of the participants were house surgeons (81(57.4%) and post graduate residents 43(30.5%) (Fig. 1). Most 129(91.5%) of the respondants had the clinical experience between one to five years ((Figure 2). They were familiar with the Stereolithographic 81(57.4%) technique of 3D printing compared to SLS29(20.6%) and FDM 11(7.8%). The most commonly fabricated prosthesis by

3D printing technology in dental practicewere temporary crowns 30(21.3%) followed by Orthodontic aligners 19(13.5%) and surgical implant guide 18(12.8%) (Table 1).

The majority of the participants were aware of the polymers PMMA 63(44.7%) and PEEK 54(38.3%) used for 3 D printing, while Zirconia126(89.4%) and Titanium alloys117(83%) were used for the fabrication of 3D printed dental prosthesis. Most participants got information about 3D printing from their workplaces, 45(64%) (Figure 3).The participants disagree104(75.2%) that 3D printed appliances were dimensionally stable. They were not satisfied 88.7% with the opinion that the undergraduate syllabus provides adequate information about 3D printing techniques (Table 1). Surprisingly during the past five years, participants rarely, 108(78%) used 3D printing technology and the majority used it once a year, 86(61%) during their clinical practice (Figures4,5,6).The respondents were of the opinion that SLA (73%) technique was used by most of the service providers for 3 Dprinting (Table 2). Three D printed temporary crowns (41.8%) were most commonly used in clinical practices followed by orthodontic aligners (13%) and surgical guides (9.2%) (Table 2). The majority of the respondents (80%) were not interested in the incorporation of 3 Dprinting technology in their clinical pratices. Similarly (89.4 %) were of the opinion3 D printing facilities were notavailable in the dental laboratories. Limited facilities were available in Lahore (15.6%) so they (10.6%) had to fabricate them from other cities (Figure 7).

Figure 1: Percentage and frequencies of demographic data

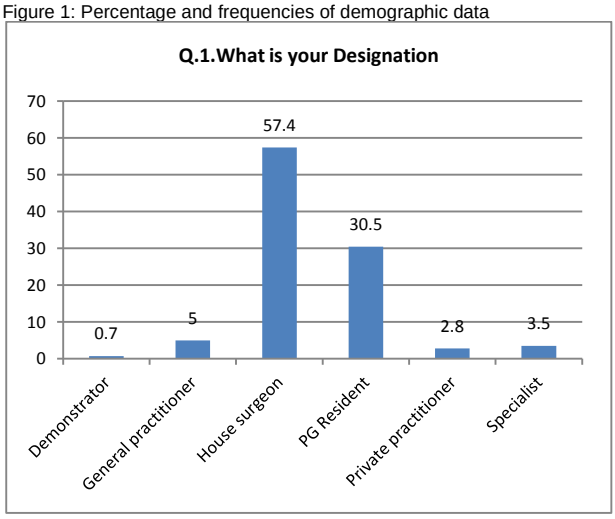
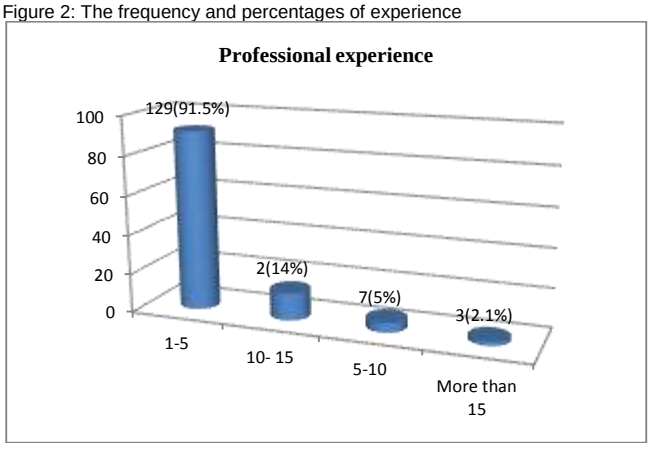


Figure 2: The frequency and percentages of experience



Options	Yes	No	Don't know
1.Are you familiar with any of the following techniques used for 3D printing			
Stereolithography	81(57.4%)	32(22.7%)	28(19.9%)
SLS	29(20.6%)	84(59.6%)	28(19.9%)
FDM	11(7.8%)	102(72.3%)	28(19.9%)
DLP	7(5%)	106(75.2%)	28(19.9%)
2.Which of the following prosthesis is commonly fabricated these days by 3D printing in Dental practice?			
3 D Model	22(15.6)	109(77.3%)	29(19.9%)
Implant surgical guide	18(12.8%)	113(80.2%)	10(7.1%)
Surgical template	18(41.1%)	113(51.8%)	10(7.1%)
Temporary crown	30(21.3%)	101(71.6%)	10(7.1%)
Special tray/ base plate	15(10.6%)	116(82.31%)	10(7.1%)
Ortho aligner	19(13.5%)	110(78%)	10(7.1%)
3.Which of the following Polymers can be 3D printed?			
PEEK	54(38.3%)	77(54.6%)	10(7.1%)
PMMA	63(44.7%)	68(48.2%)	10(7.1%)
ABS	5(3.5%)	126(89.4%)	10(7.1%)
PGLA	0.00	131(92.9%)	10(7.1%)
Which of the following ceramics can be 3-D printed?			
Zirconia	126(89.4%)	9(6.4%)	6(4.3%)
Porcelain	8(5.7%)	127(90.1%)	6(4.3%)
HA	11(7.8%)	124(87.9%)	6(4.3%)
Alumina	11(2.1%)	124(93.6%)	6(4.3%)
3.Which of the following alloys can be 3D printed?			
Titanium alloys	117(83%)	17(12.1%)	7(5%)
CoCr	16(11.3%)	118(83.7%)	7(5%)
Al alloys	9(6.4%)	125(88.7%)	7(5%)
SS	6(4.3%)	128(90.8%)	7(5%)
From where did you get information about 3D printing?			
At work	64(45.4%)	67(47.5%)	7(5%)
CDE	11(7.8%)	120(85.1%)	7(5%)
Online course	3(2.1%)	127(90.8%)	7(5%)
PG	37(26.2%)	202(66.7%)	7(5%)
Undergraduate	3(2.1%)	128(90.8%)	7(5%)
journal	12(8.5%)	119(84.4%)	7(5%)
workshop	3(2.1%)	128(90.8%)	7(5%)
Are 3-D printed appliances dimensionally stable?			
	35(24.8%)	104(75.2)	2(1.4%)
Are 3-D printed appliances cost-effective?			
	16(11.3%)	123(87.7)%	2(1.4%)
Does undergraduate syllabus provideinformation with regard to 3 D printing?			
	16(11.3%)	122(88.7%)	2(1.4%)

Figure 3: Statistical representation of information about 3D printing

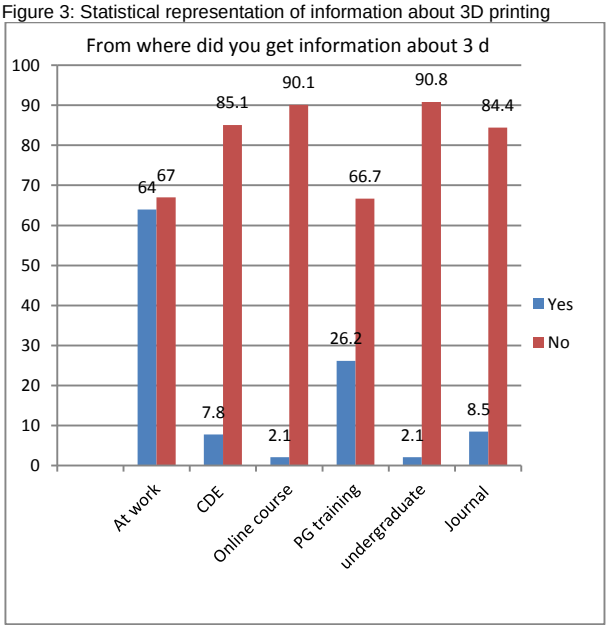


Table 1: Statistical representation of knowledge about 3 DPrinting

Figure 4: Statistical representation of perception of 3 D printing

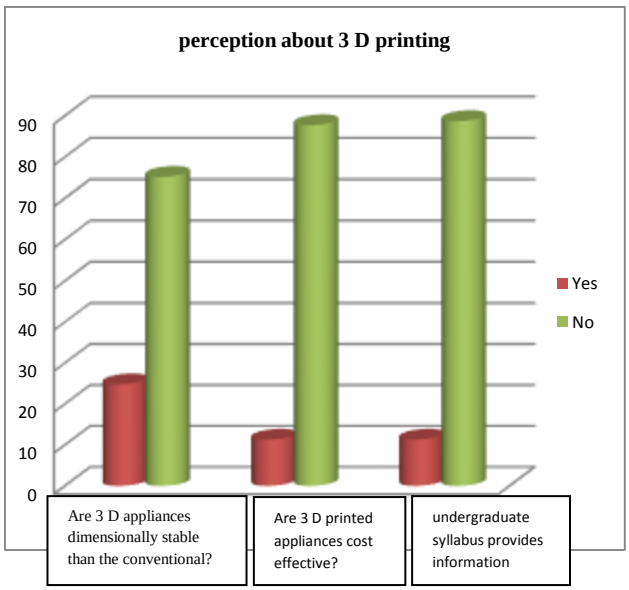


Figure 5: Statistical representations of percentages and frequencies of the practice of 3-D printing in past five years

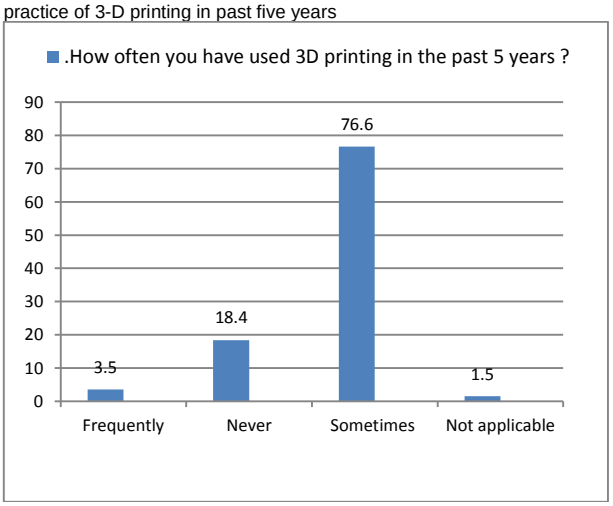


Figure 6:Frequencies and percentages of practices of 3 Printing in clinical practice

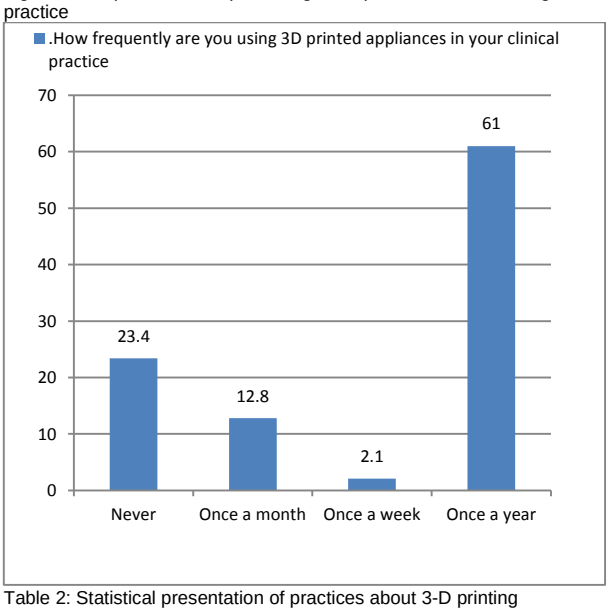
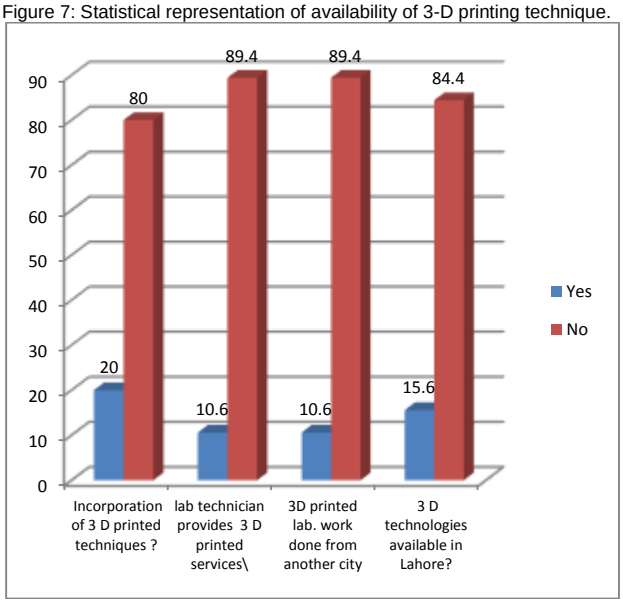


Table 2: Statistical presentation of practices about 3-D printing

	Yes (%)	No (%)	Don't know (%)
Which one of these processes 3 D printing techniques are commonly used by your service providers			
SLA	73	19.9	7.1
FDM	7.8	85.1	7.1
SLM	2.1	90.8	7.1
DLP	6.4	86.5	7.1
SLS	11.3	81.6	7.1
3D printing is used for following procedures in your practice			
Orthoaligner	13	77.3	5.7
Surgical guide	9.2	85.1	5.7
Implant surgical guide	8.5	85.8	5.7
3 D model	5.7	88.7	5.7
crown	41.8	52.5	5.7
veneers	3.5	90.8	5.7
Provisional coverage	8.5	85.8	5.7
Denture base	1.4	92.9	5.7

Figure 7: Statistical representation of availability of 3-D printing technique.



DISCUSSION

3D printing technology is gaining popularity in the field of dentistry. It involves the fabrication of different prostheses in different specialties of dentistry, such as Prosthodontics, Restorative Dentistry, Orthodontics, Maxillofacial surgery, and Implantology. Complete dentures, study models, orthodontics aligners, implant-guided surgical templates, and crowns can be fabricated with the help of this technology.[15] The most common 3D printing technologies include Stereolithography (SLA), fused deposition modeling FDM, and selective laser sintering (SLS).The different advantages of these techniques include high resolution and accuracy, a wide variety of materials that can be used, Complex structures that can be manufactured, and time efficiency. Metals, ceramics, and polymers can be used to fabricate dental prostheses[16].

Advanced imaging technologies such as CBCT, intraoral cameras, and digital scanners are already used in dentistry. Innovations like 3D printing have resulted in the production of functional prostheses rather than static ones[17]. The majority of the participants in our study needed to become more familiar with techniques used for 3D printing, such as SLS 84(59.6%), FDM 102(72.3%) and DLP 106(75.2%). In contrast to our study Dhokar et al; reported that 85.2% of the respondents were aware of this technology[18]. Most of the respondents in the current survey responded that they use 3D printing to fabricatetemporary crowns 30(21.3%) 3Dmodels 22(15.6). Dhokar et al. assessed the practices of 3D technology and reported that 43.4% were using this technology for surgical guide preparation, 78.7% were using 3-D models,and 31.3% were designing customized prostheses.

PEEK and 54(38.3%)PMMA 63(44.7%) were the most commonly used polymers, similar to our study results[18]. Pillai et al. also reported that PMMA and PEEK are the most widely used polymers.[15] Zirconia is used to fabricate ceramic prostheses, and Titanium alloys are used to fabricate crowns and cast partial dentures.[19]Majority of our participants got the information about 3Dprinting from their workplace and scientific journals. In contrast, the study conducted by Alnafisah et al reported that most 72% of respondents got information about it from workshops arranged by their institute[20]. One of the limitations for implementing 3D technology is its cost-effectiveness which has been verified by our study results. Another study by Pereira et al concluded that the 3Dprinting is the fastest method of fabrication of dental prosthesis but it is expensive as compared to conventional methods[17]. The majority of the participants 75% were of the opinion that 3Dprinted appliances were not dimensionally stable as compared to the conventional. A study by Suganna at al revealed that 21.4% of the dentist felt that 3D printed appliances were not accurate and recommended using 3D printed appliances (70%) for special cases only.[18]The majority of the respondents used the 3D printing technology very rarely in the past 5 years. The reason maybe that there are not adequate facilities available for 3D printing in Lahore [19,20] Similarly majority of our respondents used 3D printing technology only once a year in their clinics. The undergraduate syllabus for dental students does not provide information about 3D printing technology and the techniques involved. It should be incorporated into the undergraduate dental curriculum.[21] More educational workshops and seminars should be conducted to give information and hands-on training to the undergraduate and postgraduate student as well as general practitioner.

CONCLUSION

Most of our participants were unaware of 3D printing technology and its applications in dentistry. TheSLA-based fabrication technique was the most widely used for the fabrication of dental appliances. The participants were generally unaware of the materials commonly used for 3D printing. Most participants did not use 3D printing in their clinical practices. There was nocurrent information about 3D printing technology and techniques in the undergraduate syllabus and courses of teaching. Including it in the undergraduate syllabus is strongly recommended, and workshops should be arranged for hands-on training for practitioners and the faculty.

Conflict of interest: Nil

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