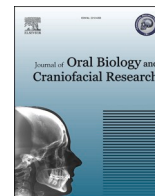




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Assessment of knowledge, awareness and practices toward the use of 3D printing among dental laboratory technicians in Karnataka, India: A cross-sectional study

Aditya Acharya, Raisa N. Chodankar^{*}, Raghunath Patil, Anandkumar G. Patil

Department of Prosthodontics and Crown and Bridge, KAHER' S KLE VK Institute of Dental Sciences, Belagavi, Karnataka, 590010, India

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ABSTRACT

With the use of CAD/CAM technology and rapid prototyping, the opportunities for digitisation and technology are unlimited. 3D printing is going to revolutionise traditional teaching and laboratory methods with rapid progress of new materials, printing technology and machines. Given the large number of options available, one must keep up with the current and emerging technology in order to make benefit of the same. The aim of the study is to assess dental laboratory technicians' knowledge, understanding and practices related the use of 3D printing in dentistry in India.

Methods: From November 2021 to January 2022, a cross-sectional questionnaire-based study was done among dental laboratory technicians in India. Dental technicians were given access to a self-explanatory questionnaire via Google forms link consisting of 12 questions that evaluated their knowledge, awareness and practices regarding 3D printing. The CHERRIES protocol for presenting the findings of the survey was followed. Chi-square test and independent t-test was used for statistical analysis by SPSS version 20.0.

Results: A total of 191 responses were obtained after the questionnaire was circulated to 220 technicians. 171 dental technicians (89.53%) were acquainted of the usage of 3D printing in dentistry. 169 (88.48%) Dental technicians preferred 3D printing to traditional procedures. Majority of dental technicians indicated they want to include the 3D printing into their regular work practices and believe digital technology will enhance our profession.

Conclusion: The level of awareness of digital dentistry and 3D printing among the participants is acceptable. Dental technicians at private laboratory showed better understanding about 3D printing as compared to technicians working at dental colleges nevertheless, dental education programmes, webinars and hands-on training should be undertaken that will enhance their expertise of 3D printing.

1. Introduction

Digitisation has engulfed the world, with its widespread applications leaving no field untouched.¹ From motivating patients to documenting their data, making digital impressions to virtual articulators, planning and fabricating prostheses, shade matching or processing restorations with Computer Aided Designing and Computer Aided manufacturing technology (CAD-CAM), rapid prototyping, and so on, there is no end to the possibilities of digitisation and technology in dentistry.^{1,2} These applications are becoming extremely worthwhile in the fields of clinical dentistry, student training, teaching, and research, laboratory

procedures, and dental research.¹ The majority of mainstream CAM systems in dentistry are using a subtractive technique which uses a cutting tool to mechanically cut the material and obtain the desired design, utilizing computer-guided commands.

The method of constructing a material layer by layer directly from 3-dimensional digital data is known as additive manufacturing (AM), often known as 3D printing or rapid prototyping.³ From dental models to surgical guides and splints, orthodontic aligners and retainers, crowns, and bridges, AM techniques are used in a plethora of dental specialties. 3D printing is also designed to make craniomaxillofacial implants, maxillofacial prosthetics, and tissue scaffolds for both hard and soft

^{*} Corresponding author. Department of Prosthodontics and Crown and Bridge, KAHER' S KLE VK Institute of Dental Sciences, JNMC Campus, Nehrunagar, Belagavi, Karnataka, 590010, India.

E-mail address: raisachodankar@gmail.com (R.N. Chodankar).

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tissue printing.^{3–7} Rapid production, high precision and customization are all benefits of 3D printing, which may be applied from complete dentures to implant dentistry.⁷ The advantages of adopting 3D printing over previous technologies include greater surface precision since worn cutting tools have no effect on precision and mass production.^{8,9} Additive manufacturing allows any object to be made, regardless of its dimensional complexity or quantity. The ability to construct light-weight prostheses that can replace heavy prostheses is perk of 3D printing. Material waste can be decreased by 40%, resulting in a positive benefit on manufacturing sustainability.³ Significant advancements in dentistry have been sparked by the emergence of AM. These technologies are now accessible to help clinicians enhance their performance.⁹ Given the advantages and broad application of 3D printing in all disciplines of dentistry, it is important to recognize its drawbacks which contribute to the slow implementation of digital technology. Customizable digitally manufactured products also conveniently minimize the waiting period that is often needed whenever the final prosthesis needs to be made using conventional ways. 3D printing can produce more promptly, and conveniently and hence is a key component of modern dentistry. Mastering 3D printing and its usage are essential for dental technicians and dental practitioner, as it allows them to choose and necessarily know what is offered, as well as how to implement it in everyday clinical practices.¹⁰

There have been surveys to evaluate dental practitioners' knowledge and practises of 3D printing in Maharashtra¹¹ and a delphi study was conducted with the goal of identifying the issues that are the most difficult to overcome when it comes to implementing 3D printing in dental practise.⁸ The goal of the present study was to assess and comprehend dental technicians' knowledge, awareness and practises regarding 3D printing.

2. Materials and methodology

2.1. Ethics statement

The Institutional Ethical Committee approval was obtained from KAHER KLE VK Institute of Dental sciences Belagavi, Karnataka, India (certificate number: 1506 dated 02/11/2021). Participants were informed of the study's goals, the length of the survey, and how long the collected data would be archived. The participants' informed consent was requested at the beginning of the form, failing which the form was redirected to the end. This study is a subset of comprehensive studies investigating current patterns and applications of 3D printing in dentistry.¹²

2.2. Study design and setting

A cross-sectional online questionnaire-based study was conducted among dental technicians working in private laboratories and at dental colleges in Karnataka, India from November 2021 to January 2022.

2.3. Study proforma and data collection

Convenience sampling method was used as the study population is small, and the institution's dental mechanics alumni contact details were obtained and the local laboratories were contacted via phone call following which, an English-language online survey was created using Google forms, and distributed to the dental technicians via email and social media sites like WhatsApp. Mandatory elements were provided in the online survey form to ensure that no responses that were incomplete were accepted. Responses were gathered and data were entered into the excel sheet using an automated process by google forms.

2.4. Questionnaire details and validation

The custom questionnaire was divided into two sections, with the

first including demographic information and the second comprising the questions. With four open-ended questions and eight closed-ended questions, questions (Q1-Q5) were beneficial in determining knowledge and awareness, while questions (Q6-Q12) were useful in determining the current clinical practice of 3D printing among dental technicians. Fig. 1 The options were arbitrarily picked in order to avoid biases. Faculty from the department of Prosthodontics, KAHER VK Institute of Dental Sciences, Belagavi, Karnataka, as well as topic experts, evaluated the questionnaire to ensure that the questions were pertinent to the topic of the survey. The questionnaire form was validated by pilot testing of a total of 50 participants which consisted of Dental technicians from private dental laboratories and dental institutions in Karnataka, India. The reliability and internal consistency of the survey were determined based on the pilot research, and a Cronbach's alpha internal consistency score of 0.81 was obtained, face validity (70%) and content validity ratio of 0.78. If there were any issues with filling out the questionnaire during the study, the researcher promptly addressed them. The final version was accepted by all the co-researchers following evaluations. The survey was devised to be finished in 5 min. The CHERRIES protocol for presenting the findings of the survey was followed.¹³

2.5. Study population and sample size estimation

Dental technicians from private dental laboratories and dental institutions in Karnataka, India were included in the study. Person other than dental technicians were excluded from the study. Participants who refused to take part in the study and who did not provide informed consent were excluded. Using information obtained from the pilot study and the formula $n = 4pq/L2$, where n is the sample size, the sample size was estimated. 190 people were included in the study.

2.6. Statistical analysis

On a Microsoft Excel document, the individual responses from each participant were gathered. The Statistical Package for the Social Sciences (SPSS) Software, version 20.0 (IBM Corp, USA), was employed for the data analysis. The frequency distribution and percentage were analysed using descriptive statistics. With a level of significance value < 0.05, the Chi-square test and independent t-test were employed to check the association between the survey questions and dental technicians.

3. Results

Following the distribution of the questionnaire in the form of a Google form link, after circulating the form link to 220 dental technicians, 191 completed responses were received, 07 did not give informed consent, and 22 did not respond. 74 individuals (38.74%) worked as dental technicians in dental colleges, whereas 117 (61.26%) engaged as dental technicians in private laboratories. In the demographic profile, we discovered that 68% of dental technicians were men, with an average experience of 2–5 years and 104 (54.4%) dental technicians were practicing in urban set-up. According to the geographical location 82 were from north interior Karnataka, 84 from south interior Karnataka and 25 were from coastal Karnataka.

The use of 3D printing in dentistry was known by 171 dental technicians (89.53%). We discovered that 18.92% of dental technicians in dental colleges and 5.13% of dental technicians in private laboratories were unfamiliar with 3D printing in dentistry, which was statistically significant using the chi-square test ($p = 0.0020$) (Table 1).

90.57% of technicians consider that 3D printing is frequently utilised to fabricate interim and permanent crowns and bridges. 53.4% of dental technicians claim to fabricate the framework for partial dentures using 3D printing, and 51.83% of dental technicians use it for fabrication of maxillofacial prosthesis Others claimed that 3D printing may be used to fabricate cranial prosthesis and occlusal wafers. (Table 2)

1 Are you aware of the use of digital technology in dentistry?
 Yes No

2 Are you aware of the use of 3D printing in dentistry?
 Yes No

3 For which product do you think 3D printing is used in dentistry?
 Definitive and interim Crown and bridge fabrication
 Implant drill guides
 Partial denture framework
 Maxillofacial prosthetics
 Occlusal splints
 Digital orthodontics
 Regenerative dentistry
 Educational tool.
 Others (please specify)

4 What are the 3D printing technologies you are aware of?
 Stereolithography (SLA, SL)
 Photopolymer jetting (PPJ)
 Selective laser sintering (SLS)
 Fused Deposition Modeling (FDM).
 Electron Beam Melting (EBM)
 Power binder printers
 Direct light processing
 Bioprinter

5 Which materials do you think are compatible with 3D printing?
 Photopolymerizing resin
 Thermoplastic polymers
 Waxes
 Metals (Titanium, Nickel chrome and cobalt chrome)
 Ceramics
 Others (please specify)

6. Do you think there is an ease of communication with the dental practitioner when it comes to 3Dprinting?
 Yes No

7. What mode of communication would you prefer to receive from the practitioner to the laboratory?
 Intra oral scan Model scan
 Others

8. Have you attended any training programs on 3D printing?
 Yes No

9. If yes , what form of training program have you attended ?
 Hands on training
 Webinars/ lectures Others

10. Would you prefer 3D printing over conventional methods?
 Yes No

11. Do you think there is a need to increase the knowledge/teaching about 3D printing during dental mechanic courses?
 Yes No

12. Are you interested in incorporating 3D printing into your regular workflow?
 Yes No

Fig. 1. Shows the custom questionnaire form including questions 1-12.

Table 1

Shows the participants' responses for awareness of the use of 3D printing in dentistry. *p-value <0.05 to be considered significant.

Awareness of the use of 3D printing in dentistry	Dental technicians At Private laboratory (n,%)	Dental technicians At dental college (n, %)	Total (n,%)	χ^2	p-value
No	6,5.13%	14,18.92%	20,10.47%	9.1960	0.0020*
Yes	111,94.87%	60,81.08%	171,89.53%		

Regarding their knowledge of 3D printing technology, 89.32% of dental technicians at private laboratories claimed they were familiar with stereolithography (SLA) and 68.21% indicated they were aware of selective laser sintering (SLS). Whereas 10.68% knew about SLA and 31.79% knew about SLS among the dental technicians working at dental colleges. Using the independent t-test p = 0.012 which was statistically significant. 7.85% of both dental technicians were acquainted with bioprinters. (Fig. 2A).

74.3% of dental technicians choose thermoplastic and 50.7% of dental technicians said metals like titanium and cobalt-chromium, are compatible with 3D printing (Fig. 2B).

With regards to ease of communication with the dentist regarding 3D printing 52.35% of dental technicians replied with yes when 47.63% disagreed.

When it comes to 3D printing communication between dental practitioners and laboratory dental technicians, 93 (79.49%) dental technicians at private laboratories prefer model scans, while 38 (51.35%) dental technicians at dental colleges believe that an intra oral scan is a better mode of communication.4.25% of the dental technicians at a private laboratory believe that, depending on the situation, CBCT is the preferred way of communication (p = 0.0001) (Table 3).

It was discovered that majority of dental technicians 84 (43.98%) had enrolled in webinars and lectures. Approximately 96 (50.26%) dental technicians had received hands-on training and had attended webinars,a majority of them were engaged at private laboratories.

Table 2

Shows descriptive statistics and comparison between dental technicians at private lab and dental technicians at dental college with respect to the participants' responses for which product they think 3D printing can be used in dentistry using independent t-test. *p-value <0.05 to be considered significant.

Product on 3D printing	Dental technicians at private lab n, %	Dental technicians at dental college n, %	TOTAL	t-value	p-value
Definitive and interim Crown and bridge fabrication	100 57.80%	73 42.20%	173	4.613	0.000*
Implant drill guides	102 77.86%	29 22.13%	131		
Partial denture framework	170 78.34%	47 21.65%	217		
Maxillofacial prosthetics	220 86.27%	35 13.73%	255		
Occlusal splints	165 90.65%	17 9.35%	182		
Digital orthodontics	173 90.57%	18 9.43%	191		
Regenerative dentistry	92 93.87%	6 6.13%	98		
Educational tool	138 100%	0 0%	138		
Others (please specify)	3 75%	1 25%	4		

(Table 3). Overall, 98.94% of dental technicians indicated they want to include the 3D printing into their regular work practices and believe digital technology will enhance the profession.

When the preference for 3D printing was compared to the technicians' laboratory experience, we discovered that 13 (18.84%) of technicians with less than 2 years of experience would not prefer 3D printing over conventional, while 6 (6.90%) and 1 (2.86%) of technicians with 2–5 years and more than 5–10 years of experience respectively

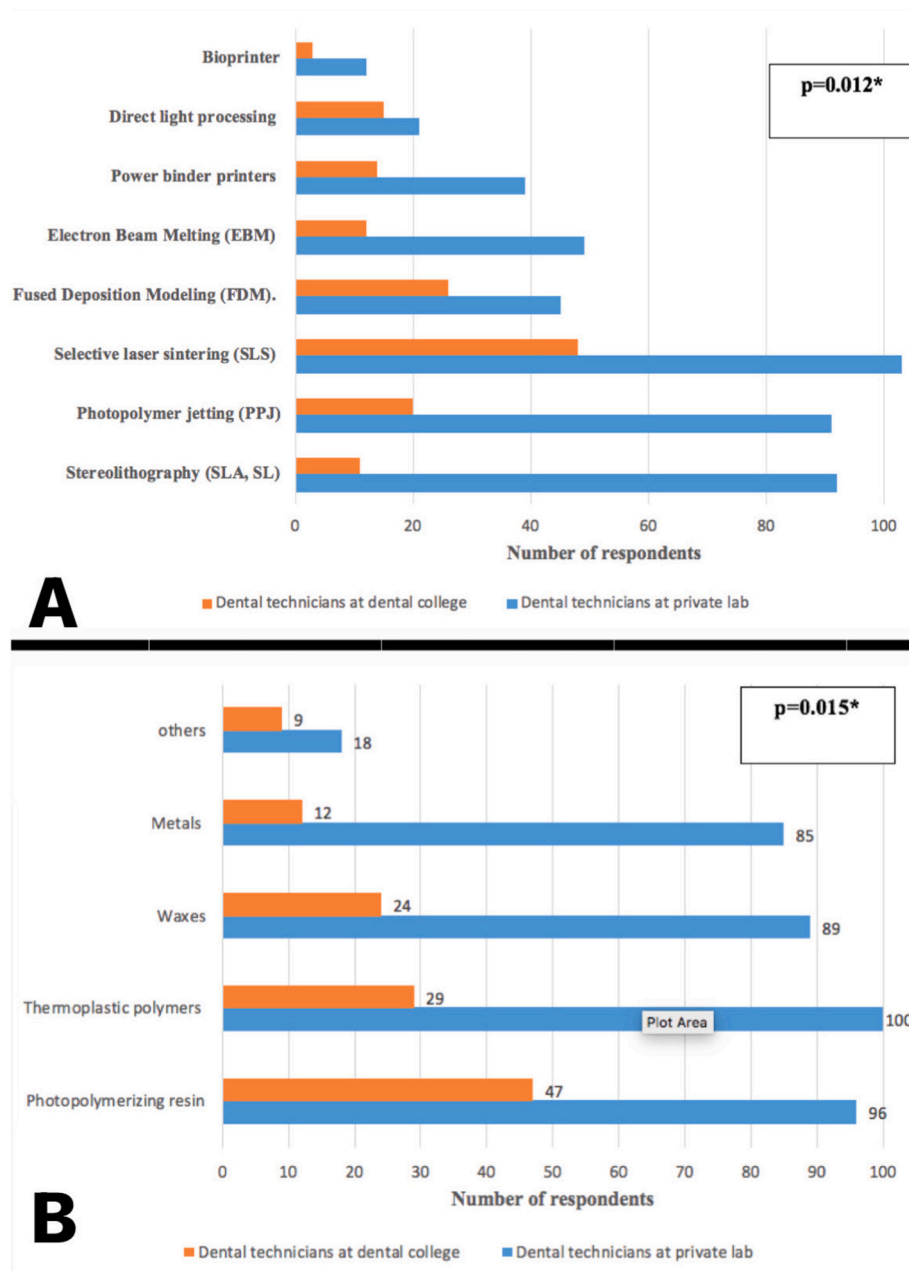


Fig. 2. A)Shows the participants’ responses for use the various technologies used in 3D printing. B) shows the participants’ responses of materials that are compatible with 3D printing. *p-value <0.05 to be considered significant.

Table 3

Shows the practice based question asked to the dental laboratory technicians. *p-value <0.05 to be considered significant.

	Dental technicians at dental college (n,%)	Dental technicians At Private laboratory (n,%)	Total (n,%)	χ^2	P- value
What mode of communication would you prefer to receive from the dentist					
Others (CBCT)	0, (0%)	5, (4.27%)	5, (2.62%)	28.272	0.0001*
Intra oral scan	38, (51.35%)	19, (16.24%)	57, (29.84%)		
Model scan	38, (48.65%)	93, (79.49%)	129, (67.54%)		
What type of training program/s have you attended on 3D printing?					
Not attended	8, (10.81%)	3, (2.56%)	11, (5.76%)	6.9590	0.0730
Hands on training	13, (17.57%)	30, (25.64%)	43, (22.51%)		
Hands on training, Webinar/lectures	19, (25.68%)	34, (29.06%)	53, (27.75%)		
Webinar/lectures	34, (45.95%)	50, (42.74%)	84, (43.98%)		

Table 4

Shows association between years of clinical experience of the dental technicians and preference of 3D printing over conventional methods. *p-value <0.05 to be considered significant.

Preference of 3D printing over conventional methods	<2 years laboratory experience	2–5 years laboratory experience	>6 years laboratory experience	χ^2	p-value
No	13 (18.84%)	6 (6.90%)	1 (2.86)	8.5060	0.0140*
Yes	56 (81.16%)	81 (93.10%)	34 (97.14%)		

considered the same ($p = 0.0140$) (Table 4).

4. Discussion

Additive manufacturing, often known as three-dimensional printing, is an advanced manufacturing technique. The use of 3D printing in dentistry can help offer patients with more tailored and lower-cost services, as well as simplify the complex workflow associated with the construction of dental products. 3D printing technologies have a broad variety of clinical applications in prosthodontics, maxillofacial surgery, oral implantology, and other domains, as well as a lot of potential and unique advantages.⁴ Given the large number of options available, one must keep up with the current and emerging technology in order to make benefit of the same. Research is required due to the dearth of studies evaluating various 3D printing practises and competence of dental professionals in India. A thorough picture of 3D printing's use in dentistry is provided by the survey, which includes dental technicians from both private dental laboratories and dental institutions. To expand the use of digital dentistry and 3D printing, this study will aid in a preliminary assessment of dental technicians' knowledge, interest, and utilisation of regional 3D printing facilities.

Parikh Maitry et al. conducted a study in India to assess the knowledge, attitude, and practices of 3D printing among orthodontists.¹⁴ According to the survey, 47.5% of orthodontists had utilised this technology, and 89% of respondents had heard of 3D printing being used specifically for the dentomaxillofacial region. While their research focuses primarily on orthodontists, the current study aims to reach dental technicians who play a key part in the product or prosthesis manufacturing.

Dhokar A et al. conducted a study to evaluate dental practitioners' knowledge and practises of 3D printing in Maharashtra according to which 85.2% of dentists are aware of the usage of 3D printing technology in dentistry.¹¹ We discovered that 89.53% dental technicians were aware of the use of 3D printing in dentistry in the current survey. This indicated that both the maker and the user were aware of the 3D printing technology.

Their research also found that 14% of respondents thought light cure resin and thermoplastic materials were the best for 3D printing. According to our survey, 54.17% of dental technicians think thermoplastic resins and 48.96% thought photopolymerizing resins are compatible.

In the current study, we found merely 7.85% of dental technicians believe that 3D printing can aid in regenerative dentistry. This could be due to a lack of understanding, training, and experience in regenerative dentistry, which is a rapidly growing area in dentistry (Table 2).

Neither of the dental technicians agree that 3D printing can be used as a teaching tool in dentistry. 3D printing can be used to produce models that mimic common case scenarios, and training on those models can enable dental practitioners and technicians acquire and develop their skills. A delphi study conducted in Germany by Klara Loges and Victor Tiberius stated that the dental technicians involved in their study were familiar with the technology and that the knowledge of 3D Printing between technician and dentist is worrisome.⁸ As the dentist without

precisely knowing which technology their laboratory or dental technician use to create the final product. The dental technicians' artistic ability and meticulous work serve as a link in bringing concepts to fruition. The majority of respondents recommended that dental mechanics students should have early training and exposure of the emerging technologies.

Although digital impressions taken with intraoral scanners have the benefit of previsualization of the preparation and lowering the risk of deformation and material waste during the impression process, we found that the majority of technicians preferred model scans. Using intraoral scanners requires high digital skills and precision. It is critical that the dentist creates a precise digital file before submitting it to the dental laboratory. Because of the added cost of the scanner and training, many dentists continue to employ traditional methods of physically transferring impressions to the dental lab.² Dental professionals will be more confident in applying the technology in routine cases if proper training and learning is offered.

4.1. Limitations

The study has some limitations, such as the fact that it is not available to those who cannot be reached via social media or e-mail. Because of the minimal number of trained dental laboratory technicians in the research population, the sample size was small. As the questionnaire cannot completely measure the depth of the participants' knowledge, this would open up opportunities to one-on-one discussions promoting sharing of knowledge and enhancing skills. The sample population has a demographic constraint in that it cannot be generalised to larger area.

4.2. Suggestions

A study with a bigger sample size would help to provide a detailed vision of the technology's incorporation in everyday dentistry. Further research should focus on clinical efficiency in terms of cost and prognosis, as well as technical issues and assessment of the patient after being managed using 3D printed models or appliances. More research can be undertaken to evaluate conventional methods with 3D printing in terms of precision and accuracy, as well as the durability of the manufactured products.

5. Conclusion

A plethora of dental restorations can be manufactured or printed using 3D printing allowing for the development of new and more efficient manufacturing methods for dental devices. The dental technicians at private laboratory showed better understanding about 3D printing as compared to technicians working at dental colleges. Dental technicians believed that more 3D printing skills should be taught in dental mechanic courses. To improve patient care, the Dental Practitioner and the Dental Technician should collaborate and fill up the voids. More research and practical training workshops is required to boost the use of digital dentistry in daily clinical practises. The more updated our knowledge, the greater service we can provide to our patients, and thereby contribute to the betterment of the dental profession.

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Declaration of competing interest

No potential conflict of interest relevant to this article was reported.

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