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Encompassing the Facets of Applicability of 3d Printing Amongst Pediatric Dentist in India

Short Title: 3D Printing in Pediatric Dentistry

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Abstract

INTRODUCTION: The constant development of new technologies in the field of medicine and health care has paved the way for the exploration of three-dimensional (3D) and four-dimensional (4D) imaging technologies in dentistry. Faster manufacturing rate and patient friendly approach of this technology has potential to revolutionize the field of pediatric dentistry.

AIM: To assess the knowledge and limiting factors of applicability of 3D printing amongst practicing pediatric dentists of India.

METHOD: A cross sectional survey was conducted among 600 randomly selected practicing pediatric dentists in India. A self-structured closed ended validated questionnaire containing 15 questions was forwarded to the participants. The questionnaire gathered data regarding demographics, knowledge, application and challenges faced by pediatric dentists for the use of 3D printing. Descriptive statistical analysis was performed using IBM SPSS version 21.0. Chi square test at 95% confidence interval and level of significance at $P<0.05$ was used to assess significance of obtained responses.

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RESULTS: Our study reported high awareness (86.7%) regarding dental 3D printing among the respondents. The working principle was known to 47.3% and more than 50% were familiar with the prerequisites for dental 3D printing. Only 38.7% had an experience of either observing or working with this technology. Majority of dentists preferred 3D printers for fabrication of space maintainer/orthodontic appliances. A statistical difference was found in knowledge and practice based on experience ($P<0.05$).

CONCLUSION: The present study manifests that knowledge and applicability of 3D printing has the potential to transform pediatric dentistry in a more predictable, minimal invasive and explicit model thereby making the diagnosis and treatment of child patients more admissible.

Keywords: 3D printing, Additive manufacturing, Pediatric dentists, Knowledge, Dentistry

INTRODUCTION

For a very long time, technology has been booming in modern dentistry. The latest technological developments have been incorporated into dental practice beyond the traditional skills of dental experts, giving patients a distinctive treatment experience. The use of 3D printers is one such technology that is utilized to completely revolutionize the production process.

The "Father of 3D Printing", Charles (chuck) Hull, created the SLA (stereo lithography apparatus) machine in 1983. Hall then formed 3D Systems and unveiled the SLA-250, the first 3D printer to be sold commercially. In 1909, the first 3D printer was made commercially available as a kit.[1] The manufacturing process of 3D printing is done by building one layer at a time which results in object formation.

3D printing is being tried in varied aspects of child management. Surgical planning and decision-making, prosthetics like hearing and hand prostheses, preterm newborn intensive care, tissue structure building and pharmaceutical printing are a few of them. By replicating the spatial orientation of anatomy for surgical approaches in cases like congenital heart disease, it facilitates management planning. It has grown in prominence due to its use in creating pediatric models and patient-specific medications.[2]

Numerous aspects of dentistry have seen a substantial application of 3D printing in clinical and laboratory settings.[3] The Pediatric dentists face many challenges while treating the child patient as children are emotionally immature and have lots of fear and anxiety associated with dental treatment. Pediatric dentistry is developing and shifting towards advanced dental treatment for better and precise performance. Amongst these advancements, the concept of 3D printing has recently emerged.

However, the adoption of any new technological innovation takes time, largely because of a lack of education and awareness. Hence this study, aimed to evaluate the knowledge and practices of pediatric dentists in India on the usage of 3D printers and their experience with it. This would help to formulate the requisites which can address its applicability and challenges thereby making pediatric dentistry friendlier to patients and clinicians.

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METHODOLOGY

The study design adopted was descriptive, cross-sectional, questionnaire-based conducted among dental practitioners in India. After getting approval from the ethical committee of the university, a self-administered questionnaire was prepared consisting of 15 questions. The questionnaire was divided into two parts with the first part including demographic data and the second contained questions regarding knowledge, attitude and practice of 3D printing technology. The questions included were close ended with either Yes/No or multiple choice responses making them distinct and easy to respond. Following validation, the formed questionnaire was forwarded to 600 practicing pediatric dentists of India through Google form link. After two gentle reminders, 489 responses were accounted for.

STATISTICAL ANALYSIS: The responses for each survey question were in the form of Categorical data which were converted into numerical data to calculate counts and percentages for statistical analysis. The analysis of the obtained data was done using non-Parametric Chi square test at 95% confidence interval and significance level at $P < 0.05$. The entire data was statistically analyzed using Statistical Package for Social Sciences (SPSS version 21.0, IBM Corporation, USA) for MS Windows.

RESULTS: A total of 489 responses were received after the questionnaire was circulated for 1 month. In the online survey form the inclusion of mandatory fields ensured that no incomplete responses were accepted.

Demographic profile of surveyed pediatric dentist in India (Table 1)

Out of the total participants, 24.5 % (n = 120) were male respondents and 75.5 % (n = 369) were female respondents. The experience of practice of respondents as a pediatric dentist for <5 years was 41.9%; 5-10 years 45.8% and >10 years 12.2%9 (n=60).

Table 1: Demographics of the study

Variable	Frequency	Percentage
Age in years		
25-30	113	23.1
31-40	332	67.9
Above 40	44	8.9
Gender		
Male	120	24.5
Female	369	75.5
Number of years in clinical practice		
<5	205	41.9
5-10	224	45.8
>10	60	12.2

Knowledge and Awareness about 3D printing (Table 2)

Out of the 489 respondents, 86.7% were aware about the use of 3D printing technology in pediatric dentistry with no significant difference in male and female respondents (P=0.768). Majority of practitioners with knowledge about working principles (47.3%) were with less than 5 years of experience (P = 0.001). No significant difference was found between the gender (P=0.445) and those with different clinical experience (P=0.053) when asked about the technologies involved in 3D printing. The knowledge about the best material for 3D printing was least amongst practitioners with a working experience of less than 5 years (24.9%) and most in those having more than 10 years (41.7) and it was statistically significant(p=0.002). More than 50% of the respondents were aware about the prime requirement of 3D printing being intra-oral scanners. The knowledge reported regarding the intraoral drug delivery system showed a significant difference with respondents with less than 10 years of working experience having more knowledge about the use and types of oromucosal films available(p=0.004).

Attitude and practice regarding the use 3D printing

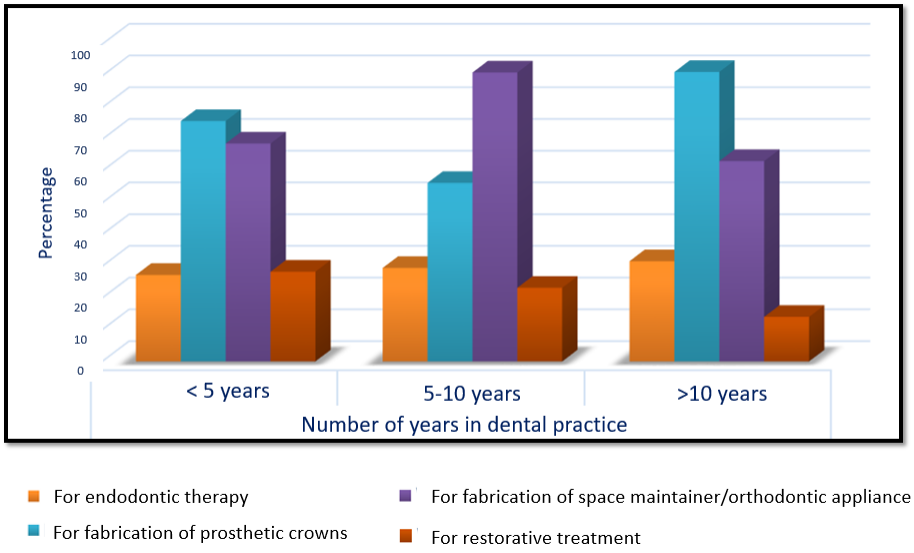
Just 29% of practitioners had an experience of either working or observing this technology, with most having an experience of less than 5 years (38.9%). (Figure 1). Majority of dentists would prefer to use 3D printers for fabrication of space maintainer/orthodontic appliances with no significant difference in the experience(p=0.066) (Figure 2). The awareness regarding the cost of one 3D printed image was seen more amongst practitioners with experience of more than 10 years (Figure 3). Major barrier or challenge for the use of this technology in the private sector according to the practitioners was the cost effectiveness followed by lack of knowledge (Figure 4). Most of the practitioners were of the opinion that 3D printing technology can bring about a change in this field with accurate diagnosis and treatment planning (Figure 5).

Questions	Responses	Variable (Male/Female)			Variable (Years of experience)			
		Male n (%)	Female n (%)	P value	<5 years n (%)	5-10 years n (%)	>10 years n (%)	P value
Are you aware about the use of 3D printing in pediatric dentistry?	a-Yes b-No	105(87.5) 15(12.5)	319(86.4) 60(13.4)	0.768 NS	165(80.5) 40(19.5)	210(93.7) 14(6.2)	49(81.6) 11(18.3)	0.001 S
What is the current working principle of 3D printing?	a-Additive manufacturing b-Rapid prototyping c-both d-not aware	40(33.3) 27(22.5) 32(26.7) 21(17.5)	112(30.4) 81(22.0) 107(29.0) 69(18.7)	0.096 NS	97(47.3) 24(11.7) 52(25.4) 32(15.6)	88(39.3) 58(25.9) 56(25.0) 22(9.8)	9(15.0) 12(20.0) 13(21.6) 26(43.3)	0.001 S
What are the technologies involved in 3D printing?	a-Stereo lithography b-Selective laser sintering c-Photopolymer jetting d-Electron beam melting e-All of the above	12(10.1) 10(8.4) 14(11.8) 11(9.2) 72(60.5)	53(14.5) 36(9.9) 27(7.4) 29(7.9) 220(60.3)	0.445 NS	39(19.0) 17(8.2) 14(6.9) 15(7.3) 120(58.6)	20(9.0) 24(10.7) 26(11.7) 19(8.4) 135(60.2)	6(10.0) 5(8.3) 4(6.7) 7(11.7) 38(63.3)	0.053 NS
Which one of the following is the most commonly used material for 3D printing?	a-Light cure resin b-Bioinorganic material c-Metal d-Thermoplastic material e-Not aware	23(19.2) 22(18.3) 14(11.7) 44(36.7) 17(14.2)	82(22.2) 66(17.9) 24(6.5) 119(32.2) 78(21.1)	0.178 NS	50(24.4) 45(22.0) 10(4.9) 51(24.9) 49(23.9)	46(20.5) 38(17.0) 22(9.8) 87(38.8) 31(13.8)	10(16.7) 6(10.0) 6(10.0) 25(41.7) 13(21.6)	0.002 S
What do you think is the prime requirement for the use of 3D printing technology?	a-CBCT b-Intraoral scanners c-Casts and models d-Clinical Photographs	25(20.8) 58(48.3) 31(25.8) 6(5.0)	73(19.7) 197(53.3) 68(18.4) 31(8.4)	0.346 NS	53(25.8) 125(61.0) 20(9.8) 7(3.4)	62(27.7) 117(52.2) 34(15.1) 11(5.0)	13(21.7) 39(65.0) 6(10.0) 2(3.3)	0.015 S

Are you aware about intraoral drug delivery system using 3D printing?	**a-Yes** **b-No**	102(85.0) 18(15.0)	304(82.3) 65(17.6)	0.949 NS	173(84.3) 32(15.6)	187(83.5) 37(16.5)	46(76.6) 14(23.3)	0.018 S
What are the types of oromucosal films?	**a-Mucoadhesive buccal films** **b-Orodispersive films** **c-Both** **d-Not aware**	13(10.8) 12(10.0) 81(67.5) 14(11.7)	50(13.7) 33(9.0) 210(57.4) 50(13.7)	0.129 NS	26(12.7) 21(10.2) 121(59.1) 37(18.0)	28(12.6) 19(8.4) 144(64.2) 33(14.8)	8(13.3) 5(8.3) 16(26.7) 31(51.7)	0.004 S

Table 2 – Knowledge and Awareness about 3d Printing Among Pediatric Dental Practitioners

Fig 1:



Experience of working or Observe 3D technology (p =0.001)

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Figure 2 – Best application of 3D printers in Pediatric Dentistry (p=0.066)

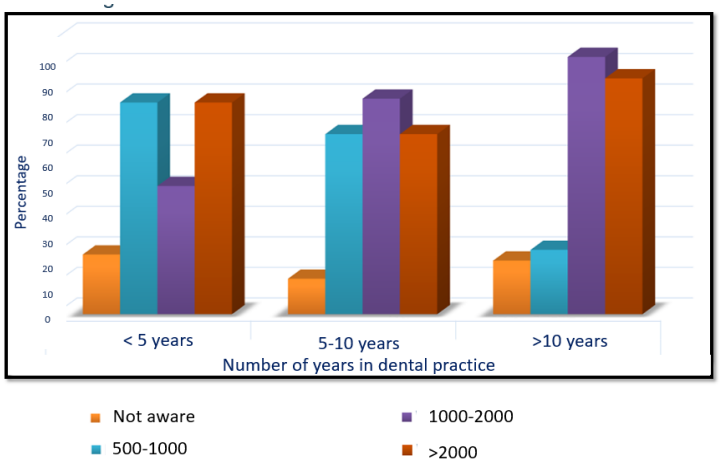

Figure 3 – Cost of one 3D printed image (p=0.001)

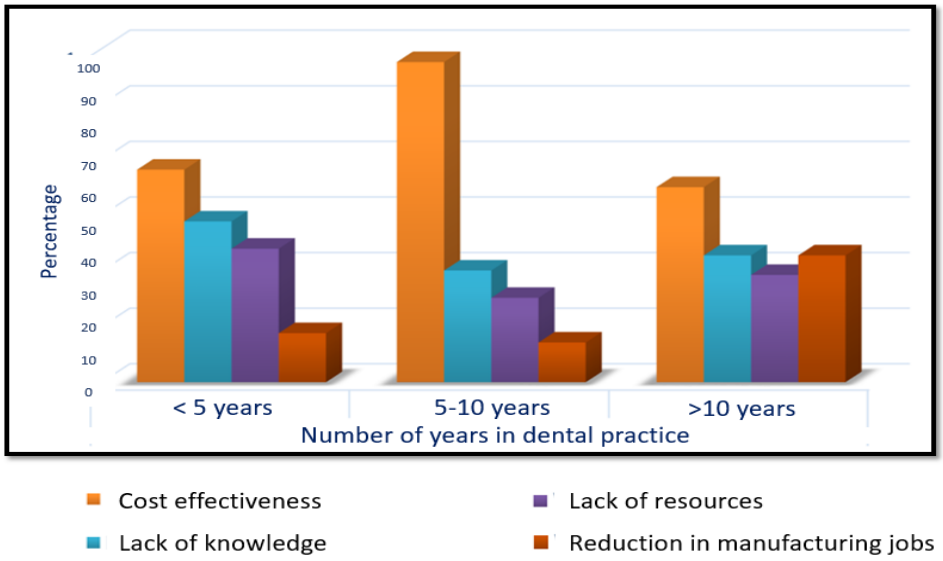

Figure 4 – Major barrier for the use of 3D printers (p=0.000)

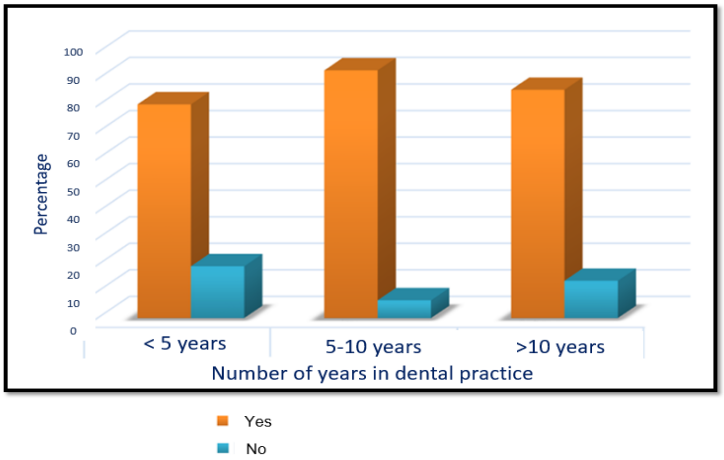

Figure 5: Can 3D printing bring about a revolution in diagnosis and treatment planning in pediatric dentistry? (p=0.461)

DISCUSSION

Newer advancements and opportunities in the field of dentistry are now paving the way towards patient-tailored treatments. For any diagnosis, treatment planning, and evaluation of treatment outcomes, clinical photographs and radiographs form the mainstay. A newer method- 3D printing has emerged and can transform diagnosis and treatment in dentistry in a more precise and predictable manner due to its advantages like rapid production, high precision and personal customization,

3D printing technique is one in which objects are built up in layers using a computer-controlled process. Materials like metal, ceramics, resin are used for this but use of thermoplastic material is on surge as they are superior in terms of biocompatibility and renders high strength to fabricated scaffolds. Additive manufacturing is based on computer-aided design (CAD) digital models and uses standardized materials to create personalized 3D objects through specific automatic processes. This technique is regularly used in a variety of industries, including aerospace, environmentally friendly construction, life-saving medical implants, and even artificial organs making using layers of human cells.4 With its use in all facets of dentistry, including the printing of surgical guides for implants, systems like Invisalign that offer an aesthetic alternative to labial fixed appliances by creating a series of personalized clear aligners for orthodontics, anatomical models, and bio-printing, forensic dentistry, etc. it is quickly gaining potential in pediatric dentistry too.5

Pediatric dentists can benefit from 3D printed models for pre-surgical planning and seeing accurate anatomy of craniofacial abnormalities.6 Delivering stem cells, creating biocompatible pulp scaffolds and creating carrier membranes for PRP will all be accomplished by additive manufacturing. Injectable calcium hydroxide molecules, growth factors and gene therapy for regenerative endodontics can all be created via 3D printing.7 Traumatic dental injuries that result in permanent tooth loss prevent implant-based

rehabilitation during the early mixed dentition phase. With a high rate of success, auto transplant protocols have recently been created. In tooth autotransplantation, 3D printed templates help to establish a guided atraumatic strategy.8,9,10

There is a lot of literature available about applications of 3D printing in dentistry but the actual knowledge of the practitioners to utilize it in routine practice is questionable. No research has been conducted on the knowledge, attitude and practices on the use of 3D printing among pediatric dentists in India. So, this study was planned in the form of a survey.

The findings of this study reveals that most of the respondents (86.7%) were aware about the use of 3D printing in pediatric dentistry but just a few i.e 29% had experience of either working or observing this technology. It was in accordance with the study done by Dhokar et al which stated that just 38.7% of practitioners had an experience of either observing or working 3D printers most being postgraduate students.11 Mucoadhesive buccal films (MBFs) and orodispersible films (ODFs) comprises oromucal films which are patient-centric dosage forms and are fabricated using printing techniques as compared to conventional solvent.12 The knowledge about working principle, prerequisites for 3D printing and oral drug delivery system was more amongst the respondents with less than 10 years of experience and this could be due to incorporation of recent advances in the study curriculum of post-graduation and more exposure of the young generation to CDEs, seminars and hands-on.

Bhaggyashri et al in 2019 reported the fabrication of band and loop space maintainer using 3D printing technology which helped in creating more accurate appliance as compared to conventional one.13 3D printing has also been described in fabrication of anterior short crowns for primary teeth.14 Most of the practitioners in our study were also of the opinion that the best use of this technology in our field can be done for the fabrication of space maintainers (39.1%) followed by fabrication of prosthetic appliances/crowns (33.5%). The reason could be that this technology helps in decreasing human errors by automating the dental model manufacturing process with three-dimensional printing. This precision achieved by the use of this technology can lead to better patient compliance and treatment results. The patients can also see and feel the three-dimensional models of corrected arches. The 3D printing requires an intraoral scanner to record the details and hence can be a boon for children with heightened gag reflex. Also, visualization of imaginative concepts through 3D models can be a great tool in motivating and educating children for oral health maintenance and makes them more admissible to the treatment approaches. Nevertheless, the factors affecting the accuracy of 3D printing including process parameters and material composition needs further research for its application in daily practice.

LIMITATIONS OF THE STUDY

The study addressed only that population who had access to email or a social media platform and a possibility of bias cannot be ignored as self-reported information is subjective in nature.

CONCLUSION

The ultimate objective of modern dentistry is to give the most technologically advanced dental treatment to the patients with the highest level of accuracy and little discomfort and 3D printing has a promising role in it. Most of the pediatric dentists thought that the use of 3D printing can bring about a revolution in pediatric dentistry but the main reason for its not being popular and scarce use of this technology in regular practice was it being expensive followed by lack of resources. It clearly indicates the need for inculcating information regarding its use and advantages in curriculum and promoting research to facilitate more affordable 3D printers.

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