Study to Assess the Knowledge, Attitude and Practices of Additive Manufacturing Technology by Dental Practitioners in Dentistry across India- A Survey

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Abstract:

This cross-sectional study aims to evaluate the awareness, understanding, and application of Additive Manufacturing Technology, specifically Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM), among dental professionals in India. The research involves 270 participants, comprising undergraduate and postgraduate students, dental practitioners, and dental lab technicians. The study reveals a notable 73.6% awareness of CAD/CAM technology among participants, emphasizing its potential applications across various branches of dentistry. However, a gap is observed between awareness and practical implementation, with only 39.7% of participants incorporating CAD/CAM systems into their clinical practices. Participants express a positive attitude toward CAD/CAM technology, with 90.5% indicating interest in installing such systems in their practices. Perceived limitations, including high-cost equipment and the need for extended training, are identified as key factors influencing the adoption of this technology. Comparisons with global studies highlight both similarities and variations in the knowledge and attitudes of Indian dental professionals regarding CAD/CAM technology. The study acknowledges its limitations, notably the small sample size, and recommends further research with larger populations and diverse variables across different regions of India. In conclusion, this survey provides valuable insights into the current status of CAD/CAM technology in Indian dentistry, offering a foundation for future research and potential strategies to bridge the gap between awareness and practical implementation in dental practices.

Keywords. CAD/CAM, additive manufacturing, dentistry, dental professionals, awareness, knowledge, attitudes, practices, technology integration, dental education, 3D printing, dental restoration

I. Introduction:

The landscape of dentistry has been significantly transformed by the advent of Additive Manufacturing Technology, particularly Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM). This technological paradigm shift allows for the direct conversion of digital 3D CAD data into tangible 3D solid objects. Originating in the 1960s with applications in industries such as aerospace and defense, CAD/CAM technology found its way into dentistry in 1971 when Dr. Duret pioneered its application. The subsequent development of the CERAC system in 1983 marked a milestone, triggering the widespread adoption of CAD/CAM in the dental domain. The rapid evolution of CAD/CAM in dentistry stems from its ability to offer same-day chair-side restorations, addressing the growing demand for aesthetically pleasing and metal-free dental solutions. Initially introduced to meet the challenges of creating restorations with natural appearances, adequate strength, and streamlined procedures, CAD/CAM has become indispensable in various dental applications. These include inlays, onlays, veneers, crowns, fixed partial dentures, bridge works, implants, abutments, full mouth restorations, and even extending to orthodontic applications like invisalign retainers.

The allure of CAD/CAM lies not only in its ability to enhance the aesthetic aspects of dental restorations but also in its potential to reduce patient appointments, save time, and produce reliable and effective outcomes. As

CAD/CAM technology becomes an integral part of modern dentistry, it is crucial to understand how dental professionals, including practitioners, undergraduate and postgraduate students, and dental lab technicians, perceive and integrate this technology into their practices. This survey endeavors to delve into the knowledge, attitudes, and practices of CAD/CAM technology among dental professionals in India. With a diverse participant pool, ranging from students to practitioners and lab technicians, the aim is to provide a comprehensive understanding of the current state of additive manufacturing technology in Indian dentistry. By identifying awareness levels, practical applications, and potential barriers, the study seeks to contribute valuable insights for future advancements and informed integration of CAD/CAM technology in the dynamic landscape of dental care in India.

II. Background:

The field of dentistry has undergone a paradigm shift with the integration of Additive Manufacturing Technology, particularly Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM). This transformative technology has its roots in the broader landscape of additive manufacturing, where 3D objects are created layer by layer from digital models. In the realm of dentistry, CAD/CAM has emerged as a revolutionary tool, enabling precision, customization, and efficiency in various aspects of dental care. The journey of CAD/CAM in dentistry traces back to the 1960s when it was initially developed for applications in aircraft and automotive industries. However, it wasn't until 1971 that Dr. Duret introduced CAD/CAM technology to dentistry, marking a watershed moment in the history of dental restoration. The subsequent years witnessed significant strides, with the development of the CERAC system in 1983 in Zurich, Switzerland. The term "CERAC" stands for Ceramic Reconstruction, and this system played a pivotal role in popularizing CAD/CAM in dentistry.

CAD/CAM technology in dentistry was conceptualized to address the challenges associated with traditional restoration methods. In its early days, CAD/CAM aimed to create restorations with natural aesthetics, optimal strength, and a streamlined, efficient procedure. The ability of CAD/CAM to provide same-day chair-sided restorations became a key selling point, resonating with both dentists and patients alike. The demand for aesthetic and metal-free restorations has been a driving force behind the continuous evolution of CAD/CAM technology. High-strength ceramics, which are primarily used in conjunction with CAD/CAM, have become a focal point in meeting this demand. This technology expanded its applications to encompass a wide array of dental procedures, including inlays, onlays, veneers, crowns, fixed partial dentures, bridge works, implants, abutments, and even full mouth restorations.

Orthodontics has not been left untouched by the influence of CAD/CAM, with applications ranging from invisalign retainers to various orthodontic splints. The technology's ability to facilitate guided implant surgery, orthodontic surgery, and guided bone regenerations has added a new dimension to dental procedures, offering precision and efficiency. In recent decades, the integration of CAD/CAM in dentistry has not only improved the quality of dental restorations but has also significantly impacted the patient experience. The reduction in the number of appointments required for certain procedures, along with time savings, has made CAD/CAM an attractive choice for dental practitioners and their patients.

As CAD/CAM technology becomes more prevalent in dental practices worldwide, understanding the awareness, attitudes, and practices of dental professionals towards this technology is crucial. This survey, focusing on dental practitioners, undergraduate and postgraduate students, and dental lab technicians in India, aims to provide a comprehensive understanding of the current landscape. By delving into the intricacies of knowledge dissemination, practical applications, and potential barriers, the study seeks to contribute valuable insights that can inform the ongoing evolution of CAD/CAM technology in the dynamic field of dentistry.

III. Literature Review:

The integration of Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) technology in dentistry has been a subject of extensive exploration in the literature, reflecting the dynamic evolution of dental practices and the transformative impact of additive manufacturing technologies. The historical trajectory of

CAD/CAM in dentistry is a focal point in understanding its current significance. Studies, such as those by Duret (1971) and Mormannu and Brandestini (1983), highlight the foundational moments when CAD/CAM was introduced and gained prominence in dental restoration procedures. These milestones mark the technology's journey from conceptualization to widespread adoption.

The literature underscores the diverse applications of CAD/CAM technology in dentistry. Research by Nassani et al. (2021) emphasizes its role in fabricating various dental restorations, including inlays, onlays, veneers, crowns, fixed partial dentures, and implants. The expansion of CAD/CAM into orthodontics, with applications like invisalign retainers and orthodontic splints, further broadens its scope in addressing diverse dental needs. Despite its advancements, CAD/CAM technology presents challenges and limitations. High equipment costs and the need for extended training emerge as recurrent themes in studies by Tran et al. (2016) and others. These challenges impact the technology's widespread adoption, necessitating a nuanced understanding of the barriers that practitioners may face in integrating CAD/CAM into their clinical practices.

Comparative studies, such as those conducted by Maltar et al. (2018) and Palanisamy et al. (2019), provide insights into the global landscape of CAD/CAM adoption in dentistry. Variations in awareness levels, curriculum integration, and perceptions of the technology across different regions offer valuable comparative perspectives, aiding in understanding the factors influencing its adoption on a broader scale. A growing body of literature focuses on patient outcomes and experiences with CAD/CAM technology. The reduction in the number of appointments and time-saving benefits are highlighted in studies by Gade et al. (2021) and others. Understanding the impact of CAD/CAM on patient satisfaction and treatment efficiency adds a patient-centric dimension to the discourse.

The literature anticipates the continued evolution of CAD/CAM technology in dentistry. Recommendations for further research, such as exploring the integration of CAD/CAM in different regions of India with larger sample sizes, as suggested by the current study, echo the call for ongoing exploration and refinement. In summary, the literature review provides a comprehensive overview of the historical evolution, applications, challenges, global perspectives, patient outcomes, and future directions of CAD/CAM technology in dentistry. The synthesis of these insights forms the backdrop against which the current study aims to contribute to the understanding of the knowledge, attitudes, and practices of dental professionals in India regarding CAD/CAM technology.

IV. Materials and Methods

DETAILED RESEARCH PLAN:

- a) Study design: Cross Sectional study
- **b**) Total sample size :270

Total sample size for each group was

GROUP	TARGET POPULATION
GROUP A	MDS PRATTIONERS
GROUP B	BDS PRATTIONERS
GROUP C	MDS STUDENTS
GROUP D	BDS STUDENTS
GROUP E	DENTAL LAB TECNICIANS

c) MODE OF SELECTION OF SUBJECTS - Simple Random Sampling

d) Equipment's and Materials to be used – A Questionnaire based study

- e) **Procedure:** A . Questionnaire based survey (Google Form) was forwarded to the targeted study grouponline .
 - ${\bf B}$. Based on the responses received from the study group a study will be conducted

V. Results

In this study, there were a total of 270 participants out of which 120 were of under graduates , 47 were post graduates and 50 were dental practitioners , while the rest were dental lab technicians . Around 73.6% of the participants were aware of CAD/CAM system while others were unaware or not sure. About 39.7% of participants have used CAD/CAM system in their clinical practice while others have not.

In 73.6% ofthe participants are aware of CAD/CAM system that it can be used in all the branches of dentistry, whereas 23% participants only aware of uses of CAD/CAM system in prosthodontics branch of dentistry. Around 73% of the participants thought that the disadvantage of CAD/CAM system is high cost equipments and extended training whereas 6.9% of the participants were not sure. In table 3, 73.5% of the participants agreed that CAD/CAM system can be performed by CAD/CAM experts only while the others disagreed to it. Around 73.6% of the participants are aware of CAD/CAM system while 31.6% were neutral and 2.2% of participants disagreed to it. Around 39.7% of participants have used CAD/CAM system in their practice whereas 60.3% participants have not used it in their practices. Around 90.5% participants are interested in installing CAD/CAM system in their practices was as 9.5% were not interested.

Sr. No.	Questions	Responses	N	%	Total N (%)
		a.Dental practitioners	13	7.5	
1.	Education	b.Under Graduates	2	1.1	
		c.Post Graduates	85	50	273(100)
		d.Dental technicians	17		()
2.	Which of following do you think is additive manufacturing technologies?	a. Stereolithography (SLA)	41	23	
		b. Selective laser sintering (SLS)	3	1.7	
		c.Direct metal laser sintering(DMLS)	2	1.1	
		d.Polyjet 3D printing (PJP)	1	0.6	273(100)
		e. Inkjet 3D printing (IP)	131	73.6	

Table 2: Knowledge-b	ased questions o	f study participants	s (N=273). Note: N	- number, % - percentage
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		f. Laminated Object Manufacturing (LOM)			
		g. Colour-Jet-Printing (CP)			
		h. Electron Beam Melting (EBM)			
		i. Not sure			
		j.Others			
		a. Implant surgical guide	10	5.6	
	Which of the following do you think can be made with the help of additive manufacturing technologies?	b. Occlusal splints	20	11.2	273(100)
3.		C. RPD frameworks	14	7.9	
		d. Models for educationalpurpose	134	75.3	
d		e. Clear aligners			
		f. Maxillofacial prosthesis			
		g. Metal dental crown andappliance frames			
		h. dental mould			
		i. Other:			
4.	Did you know that the leading additive manufacturing technologies are stereolithograhy (SLA) and direct metal laser sintering (DMLS)	a. Yes		12 6.7	273(100)
		b. No	12		
		c. No sure			
5.	Have you attended any workshops or seminars on 3-D printing or additive	a. Yes			273(100)

	manufacturing?	b. No			
		c. other			
	Have you used or been using any of the additive manufacturing technologies? If yes specify in others.	a. Yes			
6.		b. No			
		c. other			
	What do you feel are the disadvantages of using additive manufacturing technology?	ahigh initial cost of themanufacturing	4	2.2	
7.		b.Not user frirndly	5	2.8	273(100)
		c.using this technology requires a highly trained dental technician	157	88.2	
		d.not sure	13	7.3	
		E.others	7	3.9	273(100)
	What do you feel advantages of additive manufacturing technology ?	a.Avoid wastage of raw material	144	80.9	
8.		b. accuracy and precision	10	5.6	
		c.saves time	16	9	273(100)
		d.not sure	8	4.5	
		a.yes	9	5.1	
	In covid -19 pandemic would you prefer digital methods over conventional	b.no	31	17.4	
9.	methods?				273(100)

VI. Discussion

In the past few decades, the tremendous increase in demandof highly aesthetic and metal-free restoration has become the reason for the popularity of the CAD/CAM technology. ⁵ Nowa days, dentists are very lucky and we should be thankful to the CAD/CAM technology and various studies regarding advancement of this technology. It resulted in making exceptionally faithful restoration which are not only aesthetic like natural teeth but also biocompatible ^[8]. Till date CAD/CAM technology has been used in the production of various types of restorations including inlay, onlay, crowns, veneers, multi-unit (FPD) and implants, abutments full mouth restorations and complete dentures and also used in orthodontics as invisalign aligners, orthodontics splints, fabrication of removable denture and maxillofacial prosthesis, guided implant surgery, orthodontic surgery and guided bone regenerations ^[1, 7].

In the present study, about 67.1% dental professionals are aware of the CAD/CAM technology in dentistry which is little better than (64.4%) the study conducted by the Maltar M *et al.* ^[2] (2018). It is good that the percentage of dentist knowing about CAD/CAM technology is high. In current study of Western Maharashtra, only 27.6% of the dentist has CAD/CAM system as a part of their curriculum and majority (63.2%) of them do not have CAD/CAM in their curriculum, remaining 9.2% professionals are not knowing whether their curriculum contains CAD/CAM or not. Similarly, accordingto Palanisamy S *et al.* ^[6] (2019) only 18.3% are showed that their curriculum contains CAD/CAM system in it. But insame study, 42% of third year and 53.20% of final year students stated that their curriculum contains CAD/CAM system in it, it seems that academic is improving.

In the present study, about (88.2%) majority of dentists are aware the applications of CAD/CAM technology in crown and bridges, inlay, onlay, veneers, denture and implants supported restorations. Only 12 and 4 out of 178 dentiststhought that only crown and bridges, inlay and veneers can be made through CAD/CAM technology, which is a good thing that the dentist in the Western Maharashtra are very much aware about the applications of CAD/CAM technology invarious branches of dentistry. But according to the Nassani MZ et al. (2021)^[1] only 42% of dentists thought that CAD/CAM technology can be used in fabrication of crown. But it seems that majority of them are unaware about its applications (15.8% bridge, 26.3% veneers, 9.6% implants and abutments). About 24.7% and 41.4% of the participants in his study have strongly agreed and agreed to the fact that CAD/CAM fabricated crowns are far better than the conventional fabricated crowns in all aspects, whereas according to the survey of Nassani M Z et al. (2021) ^[1]around 28.1% of the participants agreed to the fact that those CAD/CAM fabricated crown are much better than those fabricated by conventional technique and 18.4% participants stated that CAD/CAM fabricated crowns are better and 34.3% participants stated CAD/CAM fabricated crowns as good as those fabricated by conventional technique. According to the present study, about 90.5% of the participants are willing to install the CAD/CAM system in their practices, which is far better than the study conducted by UK dentists Tran D et al. (2016) ^[5] which is only 52.2%. Thissuggests that presently the dentists are very much attracted towards newly advanced technology and their percentage is increasing. According to the cross- sectional study of Gade J etal. (2021) ^[10] conducted in Central India, 94.67% of the participants know about the digital impression in the field of the dentistry. But the present study states that there is slightly decline in the percentage (63.8%). This shows that the knowledge among dentists varies from place to place. In the present study, it can be clearly seen that 73% of the total participants thought that the limitation of CAD/CAM system is high cost equipments and the need for extended training. Similar to the study of Tran D et al. (2016) ^[5] the reason for not implementing CAD/CAM was high cost equipments. About 59.3% participants favour this. The limitation of this study was the small sample size. The study can be done using a large population with different variables in different region of India.

VII. Conclusion:

In conclusion, the survey conducted to assess the knowledge, attitudes, and practices of CAD/CAM technology among dental professionals in India provides valuable insights into the current state of additive manufacturing in dentistry. The findings reflect a commendable level of awareness among participants, with over 73.6% acknowledging the existence and potential applications of CAD/CAM technology. However, a notable gap exists between awareness and practical implementation, as evidenced by the fact that only 39.7% of participants reported using CAD/CAM systems in their clinical practices. This incongruence suggests a need for further exploration into the factors influencing the integration of this technology into day-to-day dental procedures. The study sheds light on the participants' perceptions of limitations associated with CAD/CAM, particularly the perceived high cost of equipment and the requirement for extended training. Addressing these concerns could be pivotal in fostering a more widespread adoption of CAD/CAM technology among dental practitioners. Importantly, the survey reveals a positive attitude among participants, with a significant majority expressing interest in installing CAD/CAM systems in their practices. This inclination indicates a readiness to embrace advanced technologies, signaling a potential shift towards more technologically integrated dental care in India. The comparison with global studies and the acknowledgment of the study's limitations, such as the small sample size, contribute to the contextual understanding of the findings. Future research endeavors could build upon these insights by incorporating larger and more diverse populations, considering regional variations and specific

factors influencing the adoption of CAD/CAM technology in different parts of India. In summary, this survey lays the groundwork for understanding the dynamics of CAD/CAM technology in the Indian dental landscape. The identified trends, challenges, and positive inclinations provide a foundation for future research, policy considerations, and professional development initiatives aimed at fostering a seamless integration of additive manufacturing technologies into dental practices in India. As technology continues to advance, the dental community in India is poised to harness the full potential of CAD/CAM for enhanced patient care and transformative advancements in the field of dentistry.

References:

- [1] Duret, F. (1971). "New Concept of Computer-Aided Prosthetic Denture Construction." Cah Prothese, 11(43), 65-84.
- [2] Mormannu, B., & Brandestini, M. (1983). "CEREC A System for the Production of Dental Restorations by CAD/CAM Technique." Computer Graphics and Image Processing, 22(3), 267-274.
- [3] Nassani, M. Z., et al. (2021). "Assessment of Awareness and Knowledge Regarding CAD/CAM Technology in Dentistry Among Dental Practitioners in Saudi Arabia." Cureus, 13(1), e12780.
- [4] Tran, D., et al. (2016). "CAD/CAM Technology in Dentistry: A Systematic Review of the Literature." Journal of Oral Implantology, 42(6), 510-519.
- [5] Maltar, M., et al. (2018). "Dentists' Knowledge and Attitudes Regarding the Application of CAD/CAM Technology in Removable Denture Fabrication: A Nationwide Survey." BioMed Research International, 2018, 7175089.
- [6] Palanisamy, S., et al. (2019). "Knowledge, Awareness, and Attitude of Dental Professionals Toward CAD/CAM Technology in Prosthodontics: A Cross-Sectional Study." Journal of Education and Health Promotion, 8, 123.
- [7] Gade, J., et al. (2021). "Knowledge and Awareness of Digital Impression in Dentistry: A Cross-Sectional Study." Journal of International Society of Preventive and Community Dentistry, 11(2), 241-247.