Medical Science

pISSN 2321–7359; eISSN 2321–7367

Knowledge, attitude and practice assessment regarding 3D imaging among dental practitioners in Saudi Arabia

Hussain Y A Marghalani[1], Horia Alghanmi[2], Sultana Alshammry[2], Abeer Alanazi[3], Salma Shahin[4], Dhuha Alshaik[5], Ammar Wali[6], Abdulmajeed Alaamri[7], Abdulmohsen Alahmari[8], Abdulaziz Alomran[9], Abdulmalik Alqazlan[10], Almaha Alniami[7], Hind Alserhan[8], Muath Saeedi[6], Khames T. Alzahrani[11]

To Cite:
Marghalani HYA, Alghanmi H, Alshammry S, Alanazi A, Shahin S, Alshaik D, Wali A, Alaamri A, Alahmari A, Alomran A, Alqazlan A, Alniami A, Alserhan H, Saeedi M, Alzahrani KT. Knowledge, attitude and practice assessment regarding 3D imaging among dental practitioners in Saudi Arabia. *Medical Science* 2023; 27: e27ms2719. doi: https://doi.org/10.54905/disssi/v27i131/e27ms2719

Authors' Affiliation:
[1]Assistant Professor and Consultant of Orthodontics, Orthodontic Department, King Abdulaziz University, Faculty of Dentistry, Jeddah, Saudi Arabia
[2]General Dentist, King Abdulaziz University, Jeddah, Saudi Arabia
[3]General Dentist, Ministry of Health, Saudi Arabia
[4]General Dentist, MSA University, Cairo, Egypt
[5]General Dentist, Riyadh Elm University, Riyadh, Saudi Arabia
[6]General Dentist, Private sector, Jeddah, Saudi Arabia
[7]Dental Intern, King Khalid University, Abha, Saudi Arabia
[8]Dental Student, King Khalid University, Abha, Saudi Arabia
[9]Dental Intern, King Saud bin Abdulaziz University, Riyadh, Saudi Arabia
[10]Dental intern, Qassim University, Qassim, Saudi Arabia
[11]BDS, PGD in Endo, Saudi Board of Endodontic, King Faisal Specialist Hospital &Research Center, Riyadh, Saudi Arabia

Peer-Review History
Received: 21 December 2022
Reviewed & Revised: 23/December/2022 to 04/January/2023
Accepted: 07 January 2022
Published: 09 January 2023

Peer-review Method
External peer-review was done through double-blind method.

URL: https://www.discoveryjournals.org/medicalscience

ABSTRACT

Background: Three-dimensional (3D) imaging has been widely utilized in dentistry to improve diagnosis, treatment planning and appliance fabrication. Technology was come increasingly important with developments in 3D imaging and modeling technology such as (CBCT), intraoral scanning and CAD/CAM. 3D imaging provides more precise and realistic diagnostic-information on craniofacial hard and soft tissue, making 3D analysis easier, faster and more reliable, to assess the knowledge, attitude and practice regarding 3D imaging in Saudi Arabian dental practitioners. *Methodology:* In our study, a Google forms online survey consisting of 25 questions was sent to orthodontists, orthodontic residents and general dentists and dental interns in Saudi Arabia. Additionally, the questionnaire was asked about dental practitioner perceptions of three-dimensional (3D) imaging. The data obtained was analyzed using the following tests: Descriptive statistics tests (frequency, mean, median and mode, range and standard deviation), chi square test. *Results:* The study included 1574 participants, 58.1% of them were males and 41.9% were females. 40.2% were intern, 38.4% had less than five years of experience, 12.4% had 5-ten years of experience and 9% had more than ten years of experience. 91.4% of participants think that 3D imaging has advantages over other digital imaging modalities. *Conclusion:* The study shows that Saudi dentists have moderate knowledge of 3D imagining in dentistry. Knowledge levels have a strong correlation with ages, practice, residence region, gender and work experience.

Keywords: 3D imaging, Orthodontics, Cone-Beam Computed Tomography, Dentists, Attitude, Knowledge, Radiology

1. INTRODUCTION

Three-dimensional (3D) imaging is frequently utilized in dentistry to assist in diagnosis, (treatment-planning) and appliance construction (Alshammery, 2020). Traditional methods for doing this required the use of impression materials together with plaster or stone models. However, more novel approaches are constantly developing and employ virtual 3D images (Ireland et al., 2008). The development of electronic 3D imaging has increased in the recent years and is used in many dental fields including restorative dentistry, orthodontics and orthognathic and craniofacial surgery (Hajeer et al., 2004). In order to make the entrance of deepness in 3D medical imaging, a collection of anatomical information is gotten using diagnostic imaging equipment, handled by a PC and then displayed on a 2D-monitor (Tanna et al., 2021).

Most Saudi dental practitioners are reluctant to incorporate the technology of (3D) printing into their clinical practice, due to the insufficient knowledge. This indicates the need of increasing the comprehension of the 3D imaging applications and understanding their various techniques in order to improve and elevate the quality of dental treatments in KSA. Limited studies have been done regarding 3D printing, imaging applications and their techniques. Therefore, further research is needed.

In diagnostic assessment, radiographs are an essential tool. To produce 3D images, we use a technology with a divergent cone-shaped x-ray beam, small machine size, high spatial resolution and short scan time called (CBCT). It has been used in many fields, but has recently been incorporated into dentistry for treatment planning and diagnosis (Joshi et al., 2020). Also, in 1915, Van Loon agreed that to determine the relationship of the dentition to the face for meaningful diagnosis and treatment planning a 3D system is required (Hajeer et al., 2004). A study conducted in the US indicated that treatment plan and diagnosis increased between 2002 and 2008 by only 11.4% when using digital models. This situation can be attributed to factors, including the learning curve required to use these systems, the lack of knowledge about these technologies by clinicians, the difficulties in qualitative assessment associated with the dose of radiation that is necessary to obtain a complete facial image software development and software development (Francisco et al., 2022).

According to a study published in 2016, Iranian dentists have limited. Knowledge and attitude regarding CBCT, despite their frequent prescription additionally, compared to those who did not use it, those who did had greater knowledge and a more positive attitude (Ghoncheh et al., 2019). In India showed that orthodontists had enough knowledge, attitudes and practices about 3D printing, however, only a few of them were fully utilizing them in their daily practices (Parikh et al., 2019). Another study among 200 students in (Dentistry-Faculty) in Marmara University suggests that the 5th year students had higher knowledge about CBCT and more optimistic attitudes at the same time as a result of the high participation rate in one year of experience, courses and seminars (Gaye-Keser and Pekiner, 2019). There are limited studies regarding this topic in Saudi Arabia. This study was conducted to enrich the literature. This study aims to assess the knowledge, attitude and practice regarding 3D imaging among dental practitioners in Saudi Arabia.

2. MATERIALS AND METHODS

Study design

This is a cross-sectional study based on a structured questionnaire that was developed by the authors and was conducted in Saudi Arabia. The survey was carried out from February to November 2022.

Inclusion and Exclusion criteria

In this study, orthodontists, orthodontic residents, general dentists and dental interns in Saudi

Sample size

The sample size was estimated using the Raosoft calculator with a confidence level of 95%, the maximum acceptable error is 0.05 and the calculated minimum sample size is 384. The Sample size was estimated using the formula: $n= P (1-P) * Z\alpha^2 / d^2$ with a confidence level of 95%;

n: Calculated sample size

Z: The z-value for the selected level of confidence (1- a) = 1.96.

P: An estimated prevalence of knowledge

Q: (1 – 0.50) = 50%, i.e., 0.50

D: The maximum acceptable error = 0.05.

So, the calculated minimum sample size was:

$n = (1.96)^2 X 0.50 X 0.50/ (0.05)^2 = 384.$

Method for data collection and instrument

Data collection Technique and tools

A questionnaire comprising 25 questions classified into three sections. The first section includes demographic details such as gender, nationality, region, age, highest level of education and work experience. The second and third sections include knowledge, attitude and practice of three-dimensional (3D) imaging respectively.

Scoring system

In our study, the knowledge was assessed using 19 questions. A score of one for each correct answer, while a score of zero for wrong or uncertain responses. The total knowledge scores for each answered question range from 1 to 19, where a score 0-6 is poor, 7-13 is Fair and 14-19 is good knowledge.

Pilot test

The opinion poll was dispersed on 20 individuals and asked to fill it. This was done to test the simplicity of the questionnaire and the feasibility of the study. Data of the pilot study was excluded from the final data of the study.

Analysis and entry method

Microsoft Excel was utilized to enter the collected data from the questionnaires. Then, the gathered data was prepared for the analysis by the Statistical Package of Social Science Software (SPSS) program, version 20 (IBM SPSS Statistics for Windows, Version 20.0 Armonk, NY: IBM Corp.) to be finally added to the results section.

3. RESULTS

The study included 1574 participants, 58.1% of them were males and 41.9% were females. 87.5% of participants were Saudi. 78.7% aged between 20- 29 years old, 15% between 30- 39 years old and 4.6% between 40- 49 years old. 40.9% of study participants were general dentists, 37.1% were dental intern, 9.3% were orthodontic residents and 7.3% were orthodontic specialists. As for work experience, 40.2% were intern, 38.4% had less than five years of experience, 12.4% had 5- 10 years of experience and 9% had more than 10 years of experience. As in Figure 1; 91.4% of participants think that 3D imaging has advantages over other digital imaging modalities.

Table 1 Socio-demographic characteristics of participants (n=1574)

Parameter		No	%
Age	less than 20	14	.9
	29- 20	1239	78.7
	39- 30	236	15.0
	49- 40	73	4.6
	60- 50	8	.5
	more than 60	4	.3
Practice	Dental intern	584	37.1
	General dentist	643	40.9
	Orthodontic consultant	85	5.4
	Orthodontic resident	147	9.3
	Orthodontic specialist	115	7.3
Gender	Male	914	58.1
	Female	660	41.9
Nationality	Saudi	1377	87.5
	Non-Saudi	197	12.5
Residence region in Saudi Arabia	Central region	509	32.3
	Eastern region	294	18.7
	Northern region	239	15.2
	Southern region	408	25.9
	Western region	124	7.9

Work experience	Intern	633	40.2
	Less than 5 years	604	38.4
	5-10 years	195	12.4
	More than 10 years	142	9.0

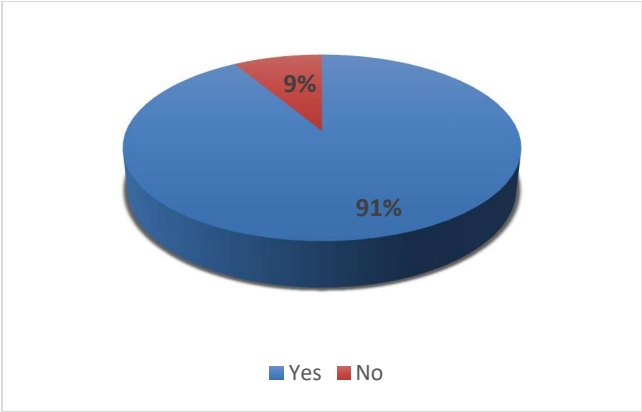

Figure 1 Advantages over other digital imaging modalities among participants regarding 3D imagining

As in Table 2, 80.1% reported high cost as disadvantage of 3D imagining while 12.5% thought it was hard to perform. Benefits of using 3D imaging was reported as less radiation dose by 19%, no developing required 28.5%, short time 35.5% and easy to store data 40.4%. 38.4% of participants think that teaching of 3D imaging for undergraduates is adequate.

Table 2 Knowledge of participants of 3D imagining in dentistry (n=1574)

Parameter		No	%
Disadvantage of 3D imaging in dental clinics	Expensive	1261	80.1
	Hard to perform	196	12.5
	None of above	117	7.4
3D imaging will be used in routine dental practice in the near future	For selected dental and orthodontics applications	585	37.2
	It will not be commonly used in routine dental and orthodontic practice	130	8.3
	In all areas of dentistry	742	47.1
	No idea	117	7.4
Cost of 3D imaging for one image	500-1000	455	28.9
	1001-1500	386	24.5
	1501-2000	229	14.5
	2000 and above	189	12.0
	No idea	315	20.0
Benefits of using 3D imaging	Less radiation dose	299	19.0
	No developing required	448	28.5
	Short time	558	35.5
	Easy to store data	636	40.4
	All of above	565	35.9
	Others	311	19.8
Heard of the use of 3D imaging used specifically for Dento maxillofacial region	Yes	1291	82.0
	No	283	18.0
Source of information regarding 3D imaging	Seminars	713	40.6
	Faculty lessons	772	44.0
	Internet	851	48.5

	Others	502	28.6
Access to 3D imaging for clinical work	Yes	904	57.4
	No	670	42.6
It is necessary for a dental 3D imaging unit to be available at locality	Yes	1318	83.7
	No	256	16.3
How often do you use 3D imaging?	Always	96	6.1
	Frequently	140	8.9
	Never	491	31.2
	Occasionally	388	24.7
	Rarely	459	29.2
Did you attend any workshops or courses regarding 3D imaging?	Yes	772	49.0
	No	802	51.0
Have you ever referred your patients for 3D imaging for any diagnosis?	Yes	1054	67.0
	No	520	33.0
Are you willing to obtain any updated information regarding 3D imaging?	Yes	1273	80.9
	No	301	19.1
Would you use 3D imaging in your future dental or orthodontic professional career?	Yes	1373	87.2
	No	201	12.8
3D imaging scanners you are familiar with	Intraoral scanning	576	32.8
	laser scanning (3D laser scanning)	352	20.1
	Convention computed and cone -beam computed tomography (CT/CBCT)	1101	62.8
	3D orthognathic surgery	362	20.6
	Vision -based scanning techniques	249	14.2
	Magnetic resonance imaging (MRI) and surface scanning	367	20.9
	Video camera (four- dimensional (4D) imaging and video stereo photogrammetry)	173	9.9
	Others	163	9.3
Teaching of 3D imaging for undergraduates is adequate	Yes	605	38.4
	No	507	32.2
	Maybe	462	29.4
It should be mandatory in dental and orthodontic clinics	Yes	1287	81.8
	No	287	18.2
3D imaging is important	Yes	1220	77.5
	No	92	5.8
	Maybe	262	16.6

As in Figure 2, 52.7% of participants use 3D imagining for Skeletal & Dental Assessment / Diagnostic purpose and only 3.60% no need for use 3D imagining scores of 3D imagining, 67.5% had moderate knowledge and 5.1% had poor knowledge.

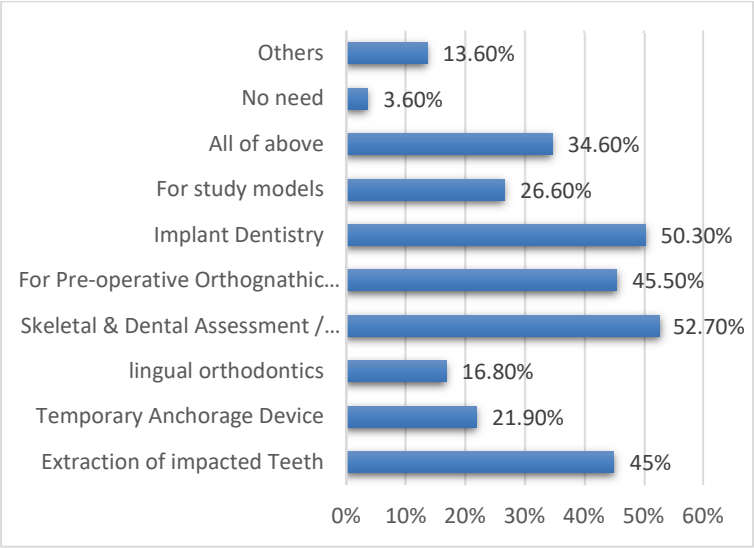

Figure 2 What cases would choose to use 3D imaging in future clinical dental practice among of participants

As in Figure 3, 27.4% of contributors had (good-knowledge-scores) of 3D imagining, 67.5% had moderate knowledge and 5.1% had poor knowledge.

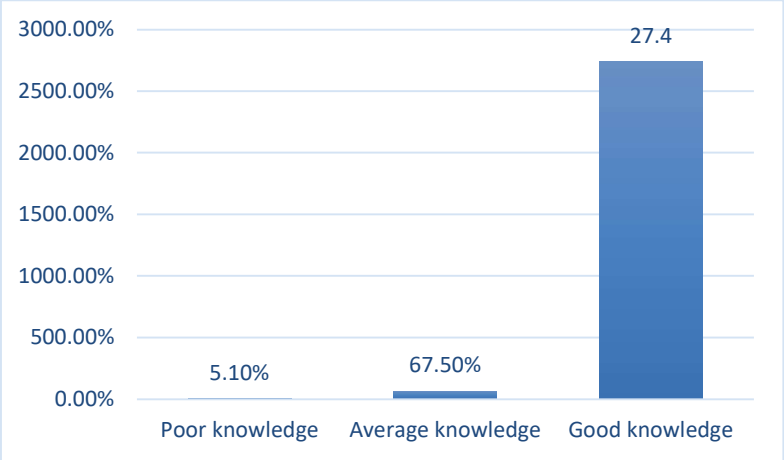

Figure 3 Knowledge scores of participants regarding 3D imagining

Knowledge scores were significantly associated with age, practice, residence region, gender and work experience (P< 0.05) (Table 3).

Table 3 Association between knowledge scores and socio-demographic characters of participants (n=1574)

		Knowledge Score			Total (N=1574)	P value
		Good knowledge	Average knowledge	Poor knowledge		
Age	less than 20	3	9	2	14	0.001
		0.7%	0.8%	2.5%	0.9%	
	29 -20	286	884	69	1239	
		66.4%	83.2%	85.2%	78.7%	
	3- 30	87	141	8	236	
		20.2%	13.3%	9.9%	15.0%	
	49- 40	52	20	1	73	
		12.1%	1.9%	1.2%	4.6%	
	60- 50	3	5	0	8	

		0.7%	0.5%	0.0%	0.5%	
	more than 60	0	3	1	4	
		0.0%	0.3%	1.2%	0.3%	
Practice	Dental intern	153	405	26	584	0.001
		35.5%	38.1%	32.1%	37.1%	
	General dentist	128	480	35	643	
		29.7%	45.2%	43.2%	40.9%	
	Orthodontic consultant	48	31	6	85	
		11.1%	2.9%	7.4%	5.4%	
	Orthodontic resident	50	88	9	147	
		11.6%	8.3%	11.1%	9.3%	
	Orthodontic specialist	52	58	5	115	
		12.1%	5.5%	6.2%	7.3%	
Nationality	Saudi	369	69	939	1377	0.412
		85.6%	85.2%	88.4%	87.5%	
	Non-Saudi	62	12	123	197	
		14.4%	14.8%	11.6%	12.5%	
Residence region	Northern region	63	162	14	239	0.001
		14.6%	15.3%	17.3%	15.2%	
	Central region	201	285	23	509	
		46.6%	26.8%	28.4%	32.3%	
	Eastern region	59	222	13	294	
		13.7%	20.9%	16.0%	18.7%	
	Southern region	84	299	25	408	
		19.5%	28.2%	30.9%	25.9%	
	Western region	24	94	6	124	
		5.6%	8.9%	7.4%	7.9%	
Gender	Male	287	583	44	914	0.001
		66.6%	54.9%	54.3%	58.1%	
	Female	144	479	37	660	
		33.4%	45.1%	45.7%	41.9%	
Work experience	Less than 5 years	121	453	30	604	0.001
		28.1%	42.7%	37.0%	38.4%	
	5-10 years	74	107	14	195	
		17.2%	10.1%	17.3%	12.4%	
	More than 10 years	70	65	7	142	
		16.2%	6.1%	8.6%	9.0%	
	Intern	166	437	30	633	
		38.5%	41.1%	37.0%	40.2%	

4. DISCUSSION

The clinical work flow of dentists is fundamentally changing as a result of recent technology advancements in the medical profession, from diagnosis to approaches to treatment plans and decision-making processes. The implementation of a comprehensive interdisciplinary approach to rehabilitation therapies is made possible by new technologies, which also improve therapy's effectiveness and efficiency and streamline routine clinical tasks (Leonardi, 2022).

In dentistry, 3D imaging is crucial for diagnosis and treatment planning. One of the foundations of this new age for dentistry and dental applications is represented by 3D imaging technologies. The clinical work flow of dental and orthodontic professionals is considerably changing as a result of the most recent advancements in 3D imaging techniques (Fourie et al., 2012).

Selective laser printing and fused deposit modeling are the main 3D-printing techniques used in the dental industry for applications like dental implants, craniofacial, maxillofacial, orthognathic and periodontal treatments, endodontic non-surgical and surgical treatments and the creation of implant copings and frameworks and dental restorations (Shalish et al., 2012).

The accuracy and efficiency of dental manufacturers' production, including that of dental aligner models, occlusal and splints, bonding trays, positional guides for minis crew insertion, on lays or veneers, etc., can be improved with the right tools (Kurenov et al., 2015).

Using laboratory-scanners or intraoral-scanners, a precise virtual representation of the prepared-tooth, implantation location, and dental arch can be created. In both fixed and removable prosthodontics, treatment can be planned and restorations can be made utilising computer-aided design technologies (Adibi et al., 2012). Using the scan data and design, (implant-abutments), bridge-structures and crown or bridge copings can all be milled or printed. Since the invention of intraoral scanning and 3D printing, the procedure of making dentures has gotten friendlier for patients (Hatcher et al., 2003). Studies show that 3D printing and electron beam or selective laser melting can successfully create metal implant prostheses (Hu et al., 2017).

Laser sintering and direct beam melting have become the most cutting-edge methods for creating customized porosity implants, including titanium mesh and reconstruction, in the field of periodontics. While 3D printing has the ability to create complex geometries, such as a bone-like morphology, that may not be able to make using milling alone, it may also be used to refine the printed shape, such as the implant platform (Kim et al., 2017; Martelli et al., 2016).

According to our study results, 27.4% of participants had good knowledge scores of 3D imagining, 67.5% had moderate knowledge and 5.1% had poor knowledge. 91.4% of participants think that 3D imaging has advantages over other digital imaging modalities. 80.1% reported high cost as disadvantage of 3D imagining while 12.5% thought it was hard to perform. Benefits of using 3D imaging was reported as less radiation dose by 19%, no developing required 28.5%, short time 35.5% and easy to store data 40.4%. A previous Saudi study with the same objective reported that, 98% of people were found to be aware that 3D printing is used in Saudi Arabian dentistry, whereas 2% were not. The placement of implants was deemed to be the most correct and least complicated treatment by 78.60% of dentists and the least accurate and most complicated procedure by 21.40% of dentists (Suganna et al., 2022). Orthodontists in India were evaluated for their 3D printing knowledge, attitudes and practices in a study by Parikh et al., (2019) claimed that 47.5% of orthodontists had used this technique; however, the current study only found that 38.7% of dental practitioners had some familiarity with it, which may be because all graduates and postgraduates were included. While the current study attempts to include all currently practicing dentists and does not restrict its use to orthodontic products, their study focuses only on orthodontists. However, 85.2% of respondents to another poll were aware of dental 3D printing. 47.6% were aware of the underlying logic. While 58.7% were not aware of the ideal material for dental 3D printing, 52.5% were aware of the prerequisites. Only 55.5% of people were aware of every signal. Only 38.7% of people had experience using this technology and of those, 78.7% felt that it had improved their ability to carry out the surgical procedure. 61.3% of respondents reported having no prior experience with this technology, primarily because it was unavailable in their field of expertise and was prohibitively expensive (Dhokar et al., 2020). Another study reported that dentists employed digital intra-oral equipment in 65% of cases. About 70% of those surveyed who perform CBCTs said they used low-dose protocols to cut back on radiation exposure. Dentists' use of low-dose regimens for CBCT devices was significantly influenced by their age and years of dental practice. In general, male dentists and dentists with more education reported feeling more at ease enchanting and interpreting (CBCT) pictures. Older dentists who had been practicing dentistry longer typically had more confidence in their ability to interpret (CBCT) images (Yeung et al., 2020).

In our study, knowledge-scores were significantly linked with ages, practice, residence region, gender and work experience ($P< 0.05$). This was comparable to a previous study reported a statistical difference was found in the knowledge and practices based on age, sex, education and experience with P value <= 0.05 (Dhokar et al., 2020).

To the best of our knowledge, there aren't any studies evaluating the understanding and usage of 3D printing among dental professionals in Saudi Arabia, so it's important to investigate. The study, which comprises dentists from all dental specialties, offers complete information about the application of this technology. Dental-professionals make-up the study population, therefore there is a higher likelihood that those who are part of it are already using this technology in their everyday work or plan to do so in the future. Response and input errors were decreased when data was gathered using online survey forms.

The survey has certain limitations in that participants who were unable to reach by email or a social media platform couldn't access it. Saudi Arabian practitioners only are included in the study population. The questionnaire focuses more on the knowledge of the practitioners than it does on the therapeutic efficacy and utility of 3D printing.

5. CONCLUSION

The study shows that Saudi dentists have moderate knowledge of 3D imagining in dentistry. Due to its extensive uses and significant promise across a wide range of dental specialties, precise knowledge of 3D printing and imaging modalities is crucial for improved treatment outcomes, patient perception and satisfaction in the dental community. Its implementation at the undergraduate and graduate levels, along with optional hands-on trainings, will ensure that dental professionals employ this technology effectively on a systemic level. The dentistry community has to be aware of 3D printing and it is imperative that it be incorporated into the curriculum. It is also advised that professors in various dental colleges take an active role in organizing specific training and orientation programmers for dentists to boost their familiarity with 3D printing and other imaging modalities. Dental professionals need to learn more about the uses and restrictions of this technology so that additional improvements can be made to get around the restrictions.

Acknowledgments

Special thanks to the Deanship of Scientific Research (DSR) and the Faculty of Dentistry at King Abdulaziz University, Jeddah, for supporting this project.

Ethical approval

The research proposal was approved by the Regional Research and Ethics committee of King Abdulaziz University, Jeddah, with letter number (129-10-22).

Funding

This study has not received any external funding.

Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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