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KNOWLEDGE AND AWARENESS REGARDING 3D PRINTING IN THE TREATMENT PLANNING OF ORTHOGNATHIC SURGERIES AMONG DENTAL PRACTITIONERS AND STUDENTS IN SAUDI ARABIA

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Abstract

Background: Dentistry has made extensive use of three-dimensional (3D) imaging to enhance diagnosis, treatment planning, and appliance production. With the advancement of 3D modeling and imaging technologies like CBCT, intraoral scanning, and CAD/CAM, technology has become more and more significant. Assessing dental professionals' knowledge and awareness regarding 3D printing in the treatment planning in Saudi Arabia is made easier, faster, and more trustworthy by the more accurate and realistic diagnostic information that 3D imaging offers on craniofacial hard and soft tissue.

Objective: This Study aimed to evaluate Knowledge and awareness regarding 3D printing in the treatment planning of orthognathic surgeries among dental practitioners and students in Saudi Arabia.

Methods: A Google Forms online survey with twenty questions. The questions were sent to specialist, Resident, General Dentist, Dental intern, and Dental students, were carried in various regions and communities across the Kingdom of Saudi Arabia. The following tests were used to examine the data: The questionnaire was validated through pilot testing. Microsoft Excel sheet. For statistical analysis, the Statistical Package for the Social Sciences (SPSS) Software version 20.0 (IBM Corp., USA) was used.

Results: Regarding the knowledge and awareness of 3D printing technology, a significant 89.2% out of 418 participants were aware of digital technology in dentistry, with 81.8% acknowledging the applications of 3D printing, particularly regarding its use in Invisalign aligners. However, 38.5% reported lacking knowledge of current 3D printing technologies, indicating a gap in awareness. A notable 88.5% preferred 3D printing over traditional methods, while 90% advocated for increased education on this subject in dental curricula. Primary knowledge sources included academic institutions (60.5%) and social media (51.9%). Barriers to implementation were identified as equipment costs (40.9%) and lack of awareness (32.3%). A large majority (66.7%) acknowledged the benefits of 3D-printed mock surgeries for surgical accuracy, and 78.7% showed interest in further exploring 3D printing applications in dentistry, reflecting a positive outlook on its integration into dental practices.

Conclusion: the study highlighted a significant awareness among dental practitioners and students in Saudi Arabia regarding the applications and advantages of 3D printing technology in orthognathic

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surgery. With 89.2% of participants familiar with digital technologies, including a strong preference for 3D printing over traditional methods, it is evident that there is a positive outlook towards integrating these modern practices into dental care. However, a notable gap remains, as 38.5% of individuals reported lacking knowledge of current 3D printing technologies.

Keywords: Knowledge, Awareness, Questionnaire, 3D printing, Orthognathic surgeries

Introduction:

Recent technological advancements have long had an impact on the field of dentistry. In addition to the general knowledge that dentists possess, modern dentistry makes use of technological advancements to provide patients with individualized care. The usage of 3D printers is another such breakthrough that will change the industrial process [1].

Alternatively known as 3D printing or additive manufacturing, this technology has revolutionized the production of customized implants, surgical guides, and prosthetic limbs. By enabling oral surgeons to customise implants and models for every patient, it enhances surgical precision and planning [2].

In the past, autologous tissue reconstruction—such as bone grafting—has been the most effective method for repairing cranial bone; but, the introduction of novel synthetic materials has made it possible to make even more important advancements in the field of reconstructive surgery [3].

In instance, skeletal disharmonies-related malocclusion problems, sleep disorders, temporomandibular joint (TMJ) disorders, and other orthodontic concerns that cannot be resolved with orthodontics are addressed by orthognathic surgery, a subspecialty of oral and maxillofacial surgery [4]. In order to enhance and alter facial traits, orthognathic surgery, also known as corrective jaw surgery, entails a variety of procedures on the jaw and jawline. Many conditions such as malocclusions, hereditary malformations, trauma-related fractures, facial misalignment, and orthodontic treatment, are now treated using orthognathic operations [5].

For a while, orthognathic surgery was performed using traditional surgical planning, or TSP. Clinical assessments two-dimensional radiography, plaster model surgery, and the creation of surgical splints are some of the steps involved in this process. Despite taking a lot of time, these procedures are effective in producing good-quality surgical results [6]. This method has limitations since 2D images cannot properly capture the intricate structure of 3D soft tissue face anatomy. Moreover, the adoption of 2D surgical designs may result in certain issues such roll and yaw rotation, midline difference, and inadequate chin, particularly in patients with facial asymmetry [7].

When compared to linear measurements gathered from lateral cephalograms, the values collected from cone-beam computed tomography (CBCT) scans have considerably closer to the real distance [8]. Numerous research studies have demonstrated the superior accuracy of virtual surgical planning (VSP) over 2D conventional surgical planning (CSP), and the usage of 3D analytic programs in VSP is growing in popularity. It has been observed that virtual surgical planning (VSP) is quicker and more affordable than conventional surgical planning (CSP), and it is also more accurate [9]. In order to maximize the benefits of 3D printing in the medical industry, a team with multiple specialties is required. Surgeons are generally not particularly knowledgeable with 3D printing, and most affordable printers require certain essential technical skills for computer-aided design (CAD) and problem-solving [10]. Traditional techniques carry certain dangers and outcomes, such as the possibility of infection, bleeding, nerve damage, poor wound healing, unfavorable movement of bone segments, and recurrence [4]. In order to improve patient outcomes and make healthcare more economical for both patients and healthcare providers, operations and healing durations need to be decreased. A new area has emerged as a result of technological developments like additive manufacturing and digital 3D modeling that have

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enhanced preoperative planning and medical care [10] . By assessing students' understanding of and use of developing technology, educational institutions may make sure that future oral surgeons have the skills to take full use of these tools by incorporating relevant courses into their teaching programs [2]. Maharashtra has done surveys to gauge the proficiency and familiarity with 3D printing among dental professionals [1]. As a result, by identifying knowledge gaps and providing baseline data that could help in the planning, implementation, and evaluation of dental practitioners' practices regarding 3D printing technology in Saudi Arabia, this knowledge, attitude, and practice (KAP) survey must act as an outline for the future workers [11].

Objective**s:**
This Study aimed to evaluate Knowledge and awareness regarding 3D printing in the treatment planning of orthognathic surgeries among dental practitioners and students in Saudi Arabia.

Materials and Methods**:**

Study design:
A cross-sectional questionnaire-based study was conducted among dental practitioners and students in Saudi Arabia.
Study setting:
Participants, recruitment, and sampling procedure:
-Participants: Dental practitioners (BDS and MDS, teaching faculty), Postgraduate students, dental students, and dental institutions in Saudi Arabia.
- Recruitment: Participants were given access to a self-explanatory questionnaire via a Google link distributed through e-mail and social media platforms.
- Sampling procedure: Convenience sampling was used

Inclusion and Exclusion criteria:
-Inclusion criteria: dental practitioners (BDS and MDS, teaching faculty), postgraduate students, and dental students.

- Exclusion criteria: Individuals other than dentists, Dental technicians from private dental laboratories and dental institutions

Sample size:
The sample size was estimated using the Qualtrics calculator with a confidence level of 95% and 5% margin of error; a sample size of 384 at least.

Method for data collection and instrument (*Data collection Technique and tools)*:
Questions assessing knowledge, awareness, and practices regarding 3D printing in dentistry.

The questionnaire was validated through pilot testing.

Scoring system:
Not specific a particular scoring system for the questionnaire responses.
Analyzes and entry method:
Individual responses were compiled on a Microsoft Excel sheet. For statistical analysis, the Statistical

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Package for the Social Sciences (SPSS) Software version 20.0 (IBM Corp., USA) was used.

Results:

Table (1) displays various demographic parameters of the participants with a total number of (418). The data reveals a diverse age distribution, with a mean age of 24.5 years (SD = 4.7), indicating a predominant representation of younger participants, specifically those between 24 to 25 years (30.6%). Gender analysis shows a significant female majority at 74.6%, highlighting potential gender dynamics within the sample population. Geographically, the Southern region is most represented (35.2%), suggesting a regional bias that may influence the findings. In terms of occupation, undergraduates constitute the majority at 56.9%, followed by general dentists and dental interns, which indicates the educational level of this cohort. Furthermore, the distribution of specialties illustrates a heavy inclination towards dental students (50.2%), potentially reflecting the focus of the study on dental education.

Table (1): Sociodemographic characteristics of participants (n=418)

Parameter		***No.***	***Percent (%)***
Age (Mean: 24.5, STD:4.7)	less than 23	98	23.4
	23 years old	95	22.7
	24 to 25	128	30.6
	more than 25	97	23.2
Gender	Female	312	74.6
	Male	106	25.4
Residential area	Northern region	71	17.0
	Southern region	147	35.2
	Center region	73	17.5
	Eastern Region	37	8.9
	Western Region	90	21.5
Occupation	Consultant	4	1.0
	Dental Intern	60	14.4
	General Dentist	88	21.1
	Resident	18	4.3
	Specialist	10	2.4
	Undergraduates	238	56.9
Speciality	Dental student	210	50.2
	Dentistry	25	6.0
	Endodontics	8	1.9
	General dentist	91	21.8
	Intern	60	14.4
	Medicine	3	.7
	Omfs	6	1.4
	Orthodontist	3	.7
	Pediatric dentistry	1	.2
	Periodontics	2	.5
	Restorative Dentistry	5	1.2
	None	4	1.0

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As shown in figure 1, The data presented indicates a significant awareness of digital technology in dentistry among the surveyed population. Specifically, 373 respondents, representing approximately 89.2%, affirm their awareness of digital technology's applications within the field. In contrast, only 45 individuals, which accounts for approximately 10.8%, indicated a lack of awareness.

Figure (1): Illustrates whether participants are aware of the use of digital technology in dentistry.

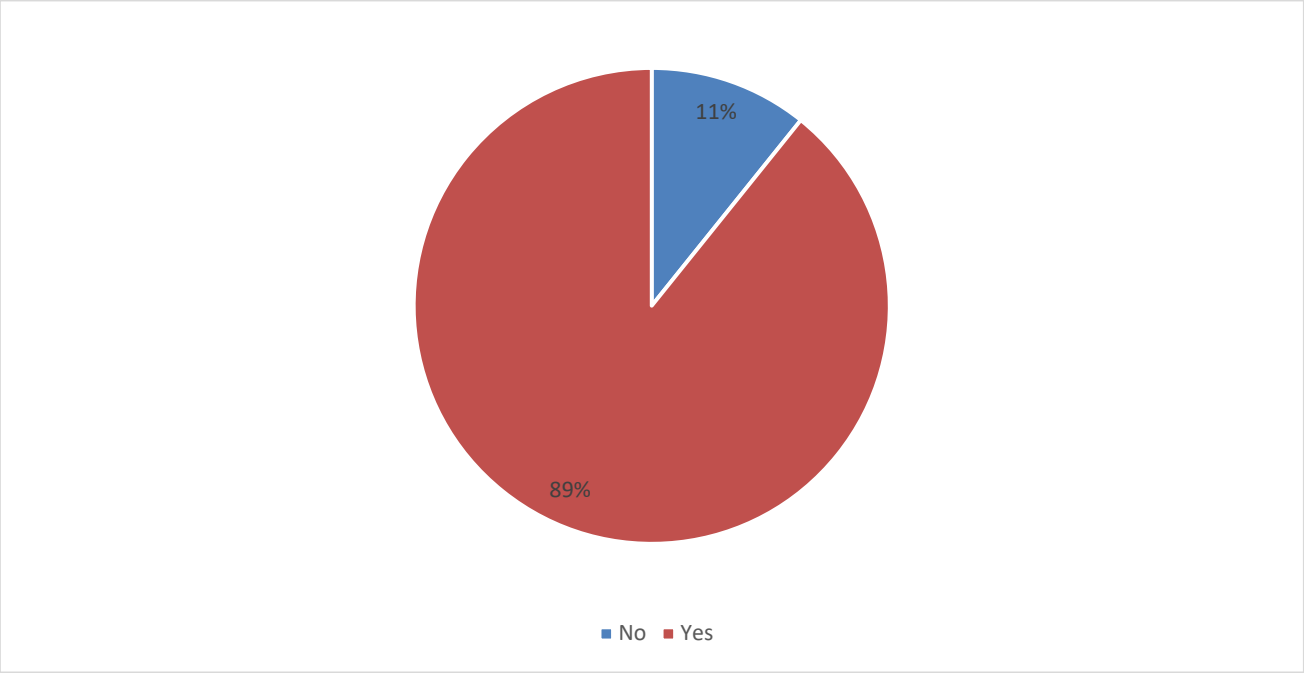

Table 2 presents insightful data on the awareness and perceptions regarding 3D printing technologies in the context of orthognathic surgeries among dental practitioners and students in Saudi Arabia, encompassing a sample of 418 respondents. A striking 89.2% of participants expressed awareness of digital technology's role in dentistry, with 81.8% recognizing the applications of 3D printing within the field. Notably, 73.9% acknowledged that Invisalign aligners utilize 3D printing, reflecting a significant understanding of modern orthodontic practices. Despite this, a considerable proportion, 38.5%, reported no knowledge of any current 3D printing technologies, indicating a potential knowledge gap. Furthermore, 88.5% of respondents preferred 3D printing over conventional methods, with a resounding 90% advocating for enhanced education on this topic within dental curricula.

Table (2): Parameters related to awareness regarding 3D printing in the treatment planning of orthognathic surgeries among dental practitioners and students in Saudi Arabia (n=418).

Parameter		***No.***	***Percent (%)***
Aware of the use of digital technology in dentistry	No	45	10.8
	Yes	373	89.2
Aware of the use of 3D printing in dentistry	No	76	18.2
	Yes	342	81.8
Aware that Invisalign (transparent aligners) used in orthodontics are 3D	No	52	12.4
	Yes	309	73.9

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printed?	I don't know	57	13.6
Current 3D printing technologies you are aware of *	Stereolithography (SLA, SL)	130	31.1
	Photopolymerizng jetting (PJJ)	66	15.8
	Selective laser sintering (SLS)	117	28.0
	Fuse deposition modeling (FDM)	66	15.8
	Electron beam melting (EBM)	68	16.3
	Powder binder printers	52	12.4
	Direct light processing	57	13.6
	Bioprinter	37	8.9
	None	161	38.5
Materials that are compatible with 3D printing *	Photopolymerizing resin	170	40.7
	Thermoplastic polymers	124	29.7
	Waxes	70	16.7
	Metals (Titanium, Nickel chrome and cobalt chrome)	90	21.5
	Ceramics	118	28.2
	Others	9	2.2
	I don't know	154	36.8
Your preferred method of communication as a dentist to the laboratory	Intraoral scan	300	71.8
	Model scan	93	22.2
	Others	25	6.0
Attended any training programs on 3D printing	No	259	62.0
	Yes	159	38.0
If yes, form of training program you have attended (n=205) *	Hands-on training	90	43.9
	Lectures	129	62.9
	Webinars	36	17.5
Prefer 3D printing over conventional methods	No	48	11.5
	Yes	370	88.5
There is a need to increase the knowledge/teaching about 3D printing during dental course	No	42	10.0
	Yes	376	90.0
Interested in incorporating 3D printing into your regular workflow	No	47	11.2
	Yes	371	88.8
You think 3D printing in dentistry is used in Saudi Arabia	No	24	5.7
	Yes	287	68.7
	Maybe	107	25.6

****Results may overlap***

As shown in figure (2), The data presented in the figure indicates a significant interest in the applications of 3D printing within the field of dentistry. Specifically, 329 respondents, representing approximately 72.1% of the total, expressed a clear willingness to explore further, showcasing a robust enthusiasm for advancements in dental technology. Conversely, 20 individuals, accounting for 4.4%, indicated they do not wish to delve deeper into this innovative domain. Additionally, a notable portion, comprising 15.3%

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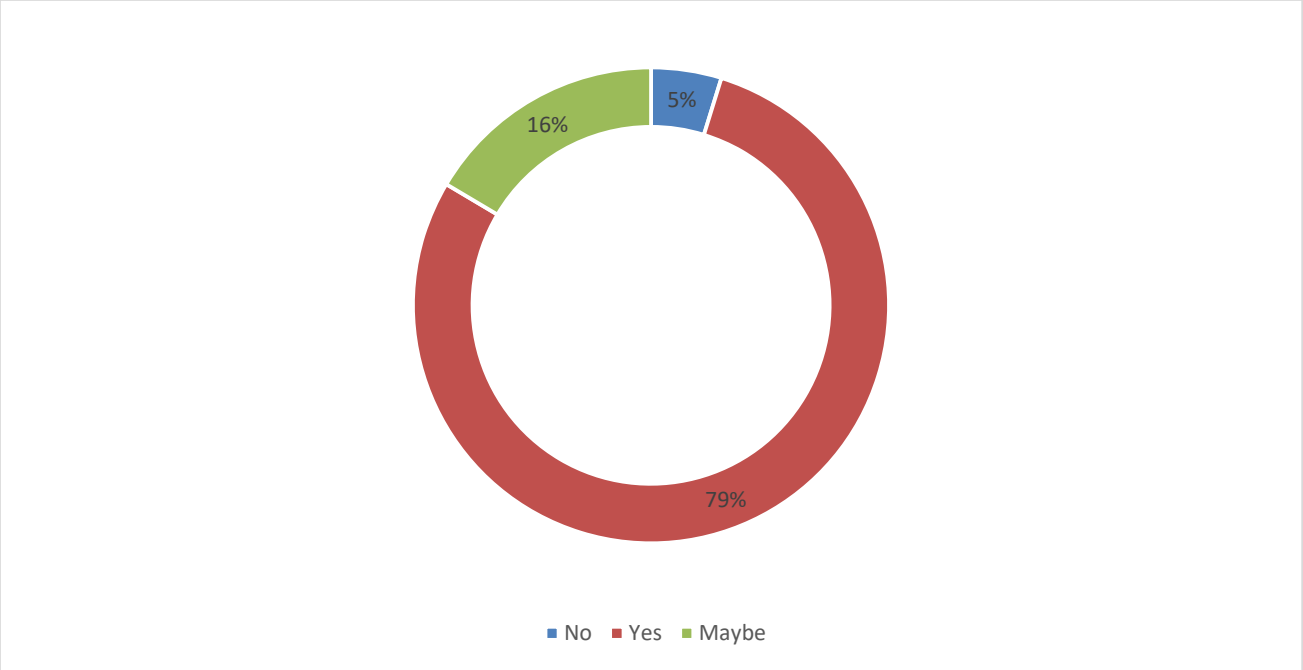
or 69 respondents, remains uncertain, categorizing their interest as "maybe."

Figure (2): Illustrates whether participants would incorporate more applications of 3D printing in dentistry



As illustrated in table (3), the table presents insightful data on the understanding and perceptions of dental practitioners and students in Saudi Arabia regarding the application of 3D printing in orthognathic surgery treatment planning. A substantial majority, 60.5%, indicated that their primary source of knowledge stems from academic institutions, with 51.9% relying on social media, highlighting the diverse channels through which knowledge is acquired. The identified barriers to adopting 3D printing, notably the cost of equipment (40.9%) and lack of awareness (32.3%), suggest critical areas for educational and policy intervention. Furthermore, an overwhelming 66.7% of participants recognized the multifaceted benefits of utilizing mock surgeries with 3D printed models, including enhanced surgical accuracy. The perception of 3D-printed implant guides as facilitating accurate procedures (87.8%) underscores a positive outlook on technological advancements in dental practices. Notably, 78.7% expressed a desire to explore further applications of 3D printing, indicating a promising interest in integrating this technology into future dental practices.

Table (3): participants' knowledge regarding 3D printing in the treatment planning of orthognathic surgeries among dental practitioners and students in Saudi Arabia (n=418).

Parameter		***No.***	***Percent (%)***
Source of information you got to know about 3D printing in dentistry *	College	253	60.5
	Clinical practice	103	24.6
	Colleagues	119	28.5
	Guest lecture	60	14.4

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	Seminar and presentations	89	21.2
	Social media	217	51.9
	Conference	104	24.9
You think the reason 3D printing is not widely used in Saudi Arabia compared with other countries in dentistry is *	Lack of awareness	135	32.3
	Cost of the equipment	171	40.9
	Complex technique	64	15.3
	All the above	188	44.9
The benefits of performing mock surgery using 3D printed models in cases of complex craniofacial fractures and surgeries *	Surgery becomes more accurate and predictable	123	29.4
	Less time spent on the operating table	88	21.0
	Patient's safety is ensured	63	15.1
	All of the above	279	66.7
3D printed implant guides make the placement of implants in	Least accurate and more complicated procedure	51	12.2
	Most accurate position and least complicated procedure	367	87.8
3D-printed drill guides and templates help treat root canal cases of calcified pulp canals	No	32	7.7
	Yes	160	38.3
	Maybe	128	30.6
	I don't know	98	23.4
3D printed materials used in dentistry will be biocompatible and have no harmful side effects in patients	No	22	5.3
	Yes	212	50.7
	Maybe	108	25.8
	I don't know	76	18.2
You would like to venture more into the applications of 3D printing in dentistry	No	20	4.8
	Yes	329	78.7
	Maybe	69	16.5

Results may overlap

Table (4) shows that being aware of the use of 3D printing in dentistry has statistically insignificant relation to gender, age, residential area and occupation.

Table (4): Relation between being aware of the use of 3D printing in dentistry and sociodemographic characteristics.

Parameters		***Are you aware of the use of 3D printing in dentistry?***		***Total (N=418)***	***P value****
		No	**Yes**		
Gender	Female	60	252	312	0.340
		78.9%	73.7%	74.6%	
	Male	16	90	106	
		21.1%	26.3%	25.4%	
Age	less than 23	17	81	98	0.458

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		22.4%	23.7%	23.4%	
	23 years old	22	73	95	
		28.9%	21.3%	22.7%	
	24 to 25	19	109	128	
		25.0%	31.9%	30.6%	
	more than 25	18	79	97	
		23.7%	23.1%	23.2%	
Residential area	Northern region	7	64	71	0.088
		9.2%	18.7%	17.0%	
	Southern region	36	111	147	
		47.4%	32.5%	35.2%	
	Central region	13	60	73	
		17.1%	17.5%	17.5%	
	Eastern Region	7	30	37	
		9.2%	8.8%	8.9%	
	Western Region	13	77	90	
		17.1%	22.5%	21.5%	
Occupation	Consultant	1	3	4	0.735
		1.3%	0.9%	1.0%	
	Dental Intern	9	51	60	
		11.8%	14.9%	14.4%	
	General Dentist	13	75	88	
		17.1%	21.9%	21.1%	
	Resident	2	16	18	
		2.6%	4.7%	4.3%	
	Specialist	2	8	10	
		2.6%	2.3%	2.4%	
	Undergraduates	49	189	238	
		64.5%	55.3%	56.9%	
Specialty	Dental student	41	169	210	N/A
		53.9%	49.4%	50.2%	
	Dentistry	5	20	25	
		6.6%	5.8%	6.0%	
	Endodontics	1	7	8	
		1.3%	2.0%	1.9%	
	General dentist	13	78	91	
		17.1%	22.8%	21.8%	
	Intern	12	48	60	
		15.8%	14.0%	14.4%	
	Medicine	1	2	3	
		1.3%	0.6%	0.7%	
	None	0	4	4	
		0.0%	1.2%	1.0%	
	Omfs	2	4	6	

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		2.6%	1.2%	1.4%	
	Orthodontist	0	3	3	
		0.0%	0.9%	0.7%	
	Pediatric dentistry	0	1	1	
		0.0%	0.3%	0.2%	
	Periodontics	0	2	2	
		0.0%	0.6%	0.5%	
	Restorative Dentistry	1	4	5	
		1.3%	1.2%	1.2%	

P value was considered significant if ≤ 0.05.

Table (5) shows that believing that 3D printing in dentistry is used in KSA has statistically significant relation to age (p value=0.027). It also shows statistically insignificant relation to gender, residential area and occupation.

Table (5): Believing that 3D printing in dentistry is used in KSA in association with sociodemographic characteristics

Parameters		***3D printing in dentistry is used in Saudi Arabia***		***Total (N=418)***	***P value****
		No or maybe	**Yes**		
Gender	Female	100	212	312	0.591
		76.3%	73.9%	74.6%	
	Male	31	75	106	
		23.7%	26.1%	25.4%	
Age	less than 23	39	59	98	0.027
		29.8%	20.6%	23.4%	
	23 years old	30	65	95	
		22.9%	22.6%	22.7%	
	24 to 25	28	100	128	
		21.4%	34.8%	30.6%	
	more than 25	34	63	97	
		26.0%	22.0%	23.2%	
Residential area	Northern region	20	51	71	0.971
		15.3%	17.8%	17.0%	
	Southern region	48	99	147	
		36.6%	34.5%	35.2%	
	Central region	23	50	73	
		17.6%	17.4%	17.5%	
	Eastern Region	11	26	37	
		8.4%	9.1%	8.9%	
	Western Region	29	61	90	
		22.1%	21.3%	21.5%	
Occupation	Consultant	3	1	4	0.499
		2.3%	0.3%	1.0%	

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	Dental Intern	19	41	60	
		14.5%	14.3%	14.4%	
	General Dentist	25	63	88	
		19.1%	22.0%	21.1%	
	Resident	5	13	18	
		3.8%	4.5%	4.3%	
	Specialist	4	6	10	
		3.1%	2.1%	2.4%	
	Undergraduates	75	163	238	
		57.3%	56.8%	56.9%	
Specialty	Dental student	64	146	210	N/A
		48.9%	50.9%	50.2%	
	Dentistry	5	20	25	
		3.8%	7.0%	6.0%	
	Endodontics	4	4	8	
		3.1%	1.4%	1.9%	
	General dentist	26	65	91	
		19.8%	22.6%	21.8%	
	Intern	21	39	60	
		16.0%	13.6%	14.4%	
	Medicine	2	1	3	
		1.5%	0.3%	0.7%	
	None	2	2	4	
		1.5%	0.7%	1.0%	
	Omfs	5	1	6	
		3.8%	0.3%	1.4%	
	Orthodontist	1	2	3	
		0.8%	0.7%	0.7%	
	Pediatric dentistry	0	1	1	
		0.0%	0.3%	0.2%	
	Periodontics	0	2	2	
		0.0%	0.7%	0.5%	
	Restorative Dentistry	1	4	5	
		0.8%	1.4%	1.2%	

P value was considered significant if ≤ 0.05.

Table (6) shows that attending training programs on 3D printing has statistically significant relation to gender (p value=0.044). It also shows statistically insignificant relation to age, residential area and occupation.

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Table (6): Attending training programs on 3D printing in association with sociodemographic characteristics.

Parameters		***Have you attended any training programs on 3D printing?***		***Total (N=418)***	***P value****
		No	**Yes**		
Gender	Female	202	110	312	0.044
		78.0%	69.2%	74.6%	
	Male	57	49	106	
		22.0%	30.8%	25.4%	
Age	less than 23	56	42	98	0.704
		21.6%	26.4%	23.4%	
	23 years old	60	35	95	
		23.2%	22.0%	22.7%	
	24 to 25	80	48	128	
		30.9%	30.2%	30.6%	
	more than 25	63	34	97	
		24.3%	21.4%	23.2%	
Residential area	Northern region	43	28	71	0.094
		16.6%	17.6%	17.0%	
	Southern region	80	67	147	
		30.9%	42.1%	35.2%	
	Central region	47	26	73	
		18.1%	16.4%	17.5%	
	Eastern Region	24	13	37	
		9.3%	8.2%	8.9%	
	Western Region	65	25	90	
		25.1%	15.7%	21.5%	
Occupation	Consultant	4	0	4	0.639
		1.5%	0.0%	1.0%	
	Dental Intern	37	23	60	
		14.3%	14.5%	14.4%	
	General Dentist	55	33	88	
		21.2%	20.8%	21.1%	
	Resident	10	8	18	
		3.9%	5.0%	4.3%	
	Specialist	5	5	10	
		1.9%	3.1%	2.4%	
	Undergraduates	148	90	238	
		57.1%	56.6%	56.9%	
Specialty	Dental student	133	77	210	0.938
		51.4%	48.4%	50.2%	

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	Dentistry	16	9	25	
		6.2%	5.7%	6.0%	
	Endodontics	4	4	8	
		1.5%	2.5%	1.9%	
	General dentist	57	34	91	
		22.0%	21.4%	21.8%	
	Intern	32	28	60	
		12.4%	17.6%	14.4%	
	Medicine	2	1	3	
		0.8%	0.6%	0.7%	
	None	3	1	4	
		1.2%	0.6%	1.0%	
	Omfs	5	1	6	
		1.9%	0.6%	1.4%	
	Orthodontist	2	1	3	
		0.8%	0.6%	0.7%	
	Pediatric dentistry	1	0	1	
		0.4%	0.0%	0.2%	
	Periodontics	1	1	2	
		0.4%	0.6%	0.5%	
	Restorative Dentistry	3	2	5	
		1.2%	1.3%	1.2%	

P value was considered significant if ≤ 0.05.

Discussion:

In the past ten years, the advancements in digitalization and three-dimensional (3D) printing have transformed dental practice [12]. The impact and potential of digitization and technology in dentistry are increasingly recognized, spanning areas such as clinical dentistry, research, student education, instruction, and laboratory procedures. 3D printing, sometimes referred to as rapid prototyping or additive manufacturing (AM), involves constructing an object by adding material layer by layer using CAD/CAM technology or advanced imaging and scanning techniques [13]. After capturing the model data with scanners or through computed tomography or cone-beam computed tomography scans, a Standard Tessellation Language (STL) file of the 3D model is generated via computer-aided design (CAD) software. This is followed by the processing and slicing of the 3D model [14]. The STL file is then sent to the 3D printer, which fabricates the product layer by layer, with the final step involving post-processing of the item [15]. This method presents numerous benefits over traditional process engineering techniques [16]. The rapid production, high precision, and customization capabilities of 3D printing make complete dentures and implant teeth more readily available. Its application in dentistry aids in simplifying the complex workflows necessary for creating dental appliances and provides more tailored experiences for patients [17]. Traditionally, restorations were produced using milling techniques until the widespread adoption of 3D printing technology. Presently, 3D-printed restorations offer various advantages. Research indicates that restorations produced through 3D printing exhibit significantly improved marginal fit and accuracy. For example, dental crowns are commonly fabricated based on standard plaster models, which yield less accuracy compared to digital scans during restoration preparation [18].Thus we aimed in this study to evaluate Knowledge and awareness regarding 3D

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printing in the treatment planning of orthognathic surgeries among dental practitioners and students in Saudi Arabia.

In our investigation, we observed that a substantial 89.2% out of 418 participants demonstrated awareness of digital technologies within the realm of dentistry. This finding stands in contrast to the study conducted by Jayadharani Chandran et al. [19], which reported a considerably lower awareness level of 58% among dental students regarding the applications of 3D printing in dental practice. This disparity underscores a notable progression in the awareness of emerging technologies, particularly among our study's participants, although it is important to note that 38.5% lacked knowledge about current technologies, reflecting a critical gap in understanding that aligns with similar trends identified in Chandran et al.'s research. The gap in awareness is significant given that both studies emphasize the importance of enhanced educational frameworks to bridge these knowledge deficiencies. Despite these concerns, a remarkable 88.5% of our participants expressed a preference for 3D printing technologies over traditional methods, reinforcing the urgent need for improved educational initiatives to elevate familiarity and expertise in these modern practices. Furthermore, our findings align with a KAP survey conducted by Mahesh Suganna et al. [20] in Saudi Arabia, wherein an astonishing 98% of dental practitioners were reported as aware of 3D printing applications in dentistry—a figure significantly surpassing the 89.2% awareness rate identified in our own study. While a notable 81.8% of our surveyed cohort acknowledged the applications of 3D printing, particularly in relation to Invisalign aligners, this contrasts with 78.6% of Saudi dentists who recognized the accuracy benefits afforded by 3D-printed implant guides. Such statistics indicate a pronounced divergence in awareness and recognition of the technology's capabilities. Intriguingly, both studies reveal a common trend: despite the comprehensive recognition of technological applications, substantial gaps in understanding persist. For instance, our study identified that 38.5% of participants were uninformed about current 3D printing technologies, paralleling the sentiment expressed by 21.4% of Saudi practitioners who regarded the complexity of these procedures as a barrier to their utilization. Moreover, both our findings and those presented by Acharya et al. [21] illustrate a compelling correlation in the realm of digital technology awareness among dental practitioners. In our study, 89.2% of participants were aware of digital technologies, while Acharya et al. reported a staggering 98.9% awareness rate among practitioners, despite some lacking specific knowledge regarding 3D printing applications. Both studies converge around a preference for 3D printing methodologies, with 88.5% of our respondents favoring these modern methods over traditional techniques. Additionally, 78.6% of Saudi dentists recognized the precision associated with 3D-printed implant guides, further demonstrating the growing acknowledgment of the advantages intrinsic to additive manufacturing in dentistry. Notably, our study showcased a strong inclination toward educational improvements, with 90% of participants expressing a desire for enhanced training in 3D printing technologies—an aspiration that resonates with Acharya et al.'s recommendations for creating venues for skill exchange among practitioners to bolster collective proficiency in these innovative practices. In a broader comparative context regarding the adoption and understanding of additive manufacturing (AM) in dentistry, Alanazi et al [22], noted that only 64.3% of faculty members were aware of AM, with a sizeable portion (33.5%) lacking fundamental understanding of the techniques. Notably, while 38.5% of our participants articulated limited knowledge about current 3D printing technologies, an alarming 71.9% of faculty members surveyed by Alanazi reported having no practical experience with AM, further accentuating the divide in educational engagement and hands-on experience. Moreover, a key finding from our study indicated a robust 90% interest in further education surrounding 3D printing, suggesting a strong motivation to enhance knowledge and integration of this technology into dental practice. This enthusiasm for educational advancement surpasses the calls raised for improved AM knowledge among Saudi faculty, demonstrating a positive shift toward embracing

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and incorporating these transformative technological advancements in contemporary dental care practices.

Conclusion:

In conclusion, this study revealed a significant awareness and interest in 3D printing technology among dental practitioners and students in Saudi Arabia, highlighting its potential to revolutionize treatment planning in orthognathic surgeries. While an impressive 89.2% of participants acknowledged digital advancements in dentistry, a notable gap in knowledge about current 3D printing technologies exists, with 38.5% expressing limited familiarity. The overwhelming preference for 3D printing over traditional methods (88.5%) and the demand for enhanced educational initiatives (90%) underscore the urgent need to address these knowledge gaps in dental curricula. Future efforts should focus on integrating comprehensive training on 3D printing technologies to ensure that dental professionals can optimize their potential, ultimately improving patient outcomes and modernizing surgical practices in the field.

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Ethical approval:

An informed consent was obtained from each participant after explaining the study in full and clarifying that participation is voluntary. Data collected were securely saved and used for research purposes only.

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Conflict of interests:

The authors declare no conflict of interest.

Informed consent:

Written informed consent was acquired from each individual study participant.

Data and materials availability:

All data associated with this study are present in the paper.

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