Oral and Implantology

A Journal of Innovations and Advanced Techniques for Oral Health

Vol. 18 | No. 1 | 2026 | pp. 75-91 | eISSN 2035-2468

Open Access

CC BY 4.0

Edikta srl

Knowledge, awareness, and practices of digital prosthodontic technologies among dental professionals in the southern region of Saudi Arabia

Khalid D ALhendi

Prosthetic Dental Science Department, Faculty of Dentistry, Najran University, Najran, Saudi Arabia

** Corresponding author: Khalid D ALhendi - kdalhendi@nu.edu.sa*

Article History

Received: October 9, 2025

Accepted: March 14, 2026

Published: June 15, 2026

DOI

https://doi.org/10.11138/oi.v18i1.219

Journal Info

eISSN 2035-2468

Peer Review: Double-blind

Published: quarterly

How to Cite

Khalid D ALhendi: Knowledge, awareness, and practices of digital prosthodontic technologies among dental professionals in the southern region of Saudi Arabia.
Oral and Implantology. 2026;18(1):75-91.
doi:10.11138/oi.v18i1.219

Abstract

Background

The integration of digital technologies has fundamentally transformed workflows within prosthodontics through the incorporation of advanced tools such as computer-aided design (CAD) and computer-aided manufacturing (CAM), intraoral scanners (IOSs), and three-dimensional printing (3D). However, a notable gap remains between awareness and actual implementation, predominantly due to financial and educational limitations. Data concerning digital prosthodontics in Saudi Arabia are limited, despite the country's emphasis on digital health initiatives under Vision 2030. This study aims to examine the knowledge, awareness, and practices (KAP) pertaining to digital prosthodontics among dental professionals in Saudi Arabia, and to compare the adoption rates of these technologies between general practitioners and specialists.

Methods

A cross-sectional online survey was conducted from May to August 2025, utilizing a validated self-administered questionnaire. Eligible participants included interns, general dentists, specialists, and faculty members from the public, private, and academic sectors within Saudi Arabia. Data analysis involved descriptive statistics and Pearson's chi-square test to evaluate associations between professional level and KAP outcomes. A p-value of less than 0.05 was considered statistically significant.

Results

A total of 204 professionals participated, most of whom were young (<25 years; 51%) and affiliated with academic institutions (53.9%). Although 57.8% of the participants were aware of digital prosthodontics, only 25.5% reported using such technologies in practice. IOSs (48.5%) and CAD/CAM (27%) were the most frequently employed instruments, particularly for crown and bridge restorations. Specialists showed significantly higher awareness and several knowledge/practice indicators than non-specialists; however, not all comparisons were statistically significant. The primary obstacles were the high initial cost (23%) and lack of training (16.7%). Notably, 79.9% of the respondents expressed interest in structured training, and 72.1% supported curricular integration.

In conclusion

Saudi dental professionals exhibit a moderate level of awareness regarding digital prosthodontics; however, their clinical application predominantly remains within the realm of specialists. The principal barriers comprise financial, educational, and institutional challenges. Opportunities exist to enhance adoption through the promotion of enthusiasm for curricular reforms and training initiatives. By emphasizing structured education, accessible training programs, and cost-sharing strategies, Saudi prosthodontics can advance patient care and align with international digital standards.

The clinical significance lies in bridging the divide between awareness and the adoption of digital prosthodontics, which is vital for the advancement of clinical practice. Improving educational opportunities and minimizing financial barriers can lead to better patient outcomes, more efficient workflows, and expanded access to digital care outside specialist environments.

Keywords: Adoption barriers, CAD/CAM technology, Dental education, Digital prosthodontics, Digital workflows, Intraoral scanners.

Introduction

Modern dental practice has experienced a profound transformation attributable to digital technologies, which have revolutionized diagnostic procedures, treatment planning, and the fabrication of restorations. Prosthodontics is a specialized discipline focused on restoring oral function, aesthetics, and health in patients presenting with missing or deficient teeth and maxillofacial structures. Developments within prosthodontics have significantly enhanced accuracy, efficiency, and patient-centered outcomes. Furthermore, digital workflows are increasingly recognized as essential components of contemporary prosthodontic care. [1-3]

Computer-aided design (CAD) and computer-aided manufacturing (CAM), intraoral scanners (IOS), cone-beam computed tomography (CBCT), and three-dimensional (3D) printing exemplify some of the advanced digital tools that have progressively replaced traditional analog techniques. Collectively, these technologies enhance the accuracy and consistency in fixed, removable, and implant prosthodontics. Furthermore, applications such as virtual articulators and digital occlusal analysis expand diagnostic and treatment-planning capabilities. [4-7] These advancements are widely recognized for their ability to improve workflow efficiency and patient outcomes. [8-9]

Nevertheless, a persistent disparity remains between the awareness of digital technologies and their integration into routine clinical practice despite these advancements. Surveys conducted internationally consistently demonstrate that although most clinicians are willing to adopt digital approaches, barriers such as high equipment costs, steep learning curves, and a lack of standardized training persist. These findings indicate that clinicians are receptive to innovation; however, the widespread adoption remains constrained by educational and systemic limitations. This issue is particularly significant in Saudi Arabia, where digital health has been identified as a strategic priority in the modernization of healthcare delivery under Vision 2030. [15]

Nonetheless, the implementation of digital dentistry persistently encounters constraints; practitioners and academic staff overseeing clinical education exhibit unequal access to cutting-edge technologies and possess limited opportunities for practical training. [16-17] Collectively, these observations imply that the integration of digital dentistry within Saudi Arabia is hindered by persistent structural obstacles, including inadequate institutional investment and restricted practical exposure.

Moreover, existing Saudi studies frequently conduct preliminary examinations of digital dentistry or focus on isolated technologies, such as CAD/CAM or IOSs, rather than assessing the integration of digital tools within prosthodontic workflows. This narrow scope results in a significant evidence gap: the specific manner in which dental professionals in Saudi Arabia engage with digital prosthodontics across the fixed, removable, and implant subspecialties, and the degree to which adoption is affected by role, experience, and practice setting. Efforts to reform curricula, expand professional training, and develop supportive policies risk being fragmented or inadequately targeted in the absence of such evidence.

Consequently, this study aimed to evaluate the knowledge, awareness, and practices (KAP) of dental professionals in Saudi Arabia concerning digital prosthodontics. Furthermore, the research examined differences contingent upon experience, specialization, and practice environment. The findings are intended to identify opportunities and challenges associated with adoption, to inform curriculum and training reforms, and to enhance the broader understanding of the integration of digital dentistry. [30-33]

Methodology

Study Design and Setting

A structured self-administered online questionnaire was utilized in this cross-sectional analytical study to evaluate the clinical practices, knowledge, and awareness of digital prosthodontics among dental professionals in Saudi Arabia. The study complied with the STROBE guidelines for observational research. [20] All responses were secured with password protection, anonymized, and processed in accordance with the Declaration of Helsinki. [21]

Eligible participants encompassed interns, general dentists, prosthodontists, and other specialists from public, private, and academic sectors. Undergraduate students who had not yet begun their internships were excluded. Participation was voluntary, and electronic informed consent was obtained prior to access to the survey.

Sample Size and Power Calculation

The Saudi Commission for Health Specialties reported that the number of dentists in the Southern region of Saudi Arabia in 2023 was approximately 43,000. [22] The Raosoft calculator (Raosoft, Inc., Seattle, WA, USA) indicated that a minimum sample size of 381 was required to achieve a 95% confidence interval and a 5% margin of error. A total of 228 responses were collected, and 24 were excluded due to incompleteness or inconsistency, resulting in 204 valid responses. The margin of error was 6.85%. Although this exceeds the standard 5%, it was deemed acceptable for exploratory cross-sectional sur-

https://doi.org/10.11138/oi.v18i1.219

veys in dentistry. The obtained sample size provides sufficient statistical power to detect medium effect sizes.

Participants and Recruitment

A non-probability convenience sampling technique was utilized. The survey link was disseminated via professional dental networks, academic institutions, and various social media platforms (e.g., WhatsApp, Twitter/X, Telegram, and Facebook) to ensure extensive outreach across diverse practice environments. This methodology has been extensively employed in exploratory surveys involving healthcare professionals where a probability-based framework is absent. [10,19] Data collection was conducted anonymously from May to August 2025 through Google Forms.

Survey Instrument Development and Validation

The questionnaire was derived from previously validated instruments on digital dentistry adoption [10-13,16,18-19] and tailored specifically to emphasize prosthodontics. Content validity was confirmed by a panel comprising two prosthodontics faculty members and one health education specialist. Each item was evaluated for clarity, relevance, and necessity using a 4-point Likert scale. The thresholds for Content Validity Index were met (I-CVI ≥ 0.78; S-CVI/Ave ≥ 0.80). [23] A pilot study involving 30 dental practitioners, comprising interns, general dentists, and specialists, was conducted to assess flow, comprehensibility, and completion time. Subtle adjustments were implemented in response to feedback. The final instrument's internal consistency was validated with a Cronbach's α of >0.70, indicating good reliability. [24]

Questionnaire Parts

In order to address the multicultural and diverse academic backgrounds of Saudi Arabia's dental workforce, the structured questionnaire was meticulously designed in English and systematically categorized into four distinct domains. The initial section collected demographic and professional data, including age, gender, qualifications, clinical experience, specialty, and practice setting. The second section evaluated knowledge of digital prosthodontics, emphasizing familiarity with the concept, awareness of specific technologies such as CAD/CAM systems, IOSs, 3D printing, and virtual articulators, as well as the sources from which participants acquired this knowledge. The third section concentrated on awareness, examining recognition of digital workflows, applications, and advantages, including inquiries related to CAD/CAM-fabricable prostheses, perceived benefits of IOSs, clinical applications of 3D printing, implant planning instruments, and the roles of digital dentures and virtual articulators. The fourth section assessed practice-related factors, encompassing participants' current utilization of digital prosthodontic technologies, clinical indications for their employment, duration of experience, self-rated confidence, perceived barriers to adoption, and perspectives on training requirements and curricular integration.

Data Management and Statistical Analysis

Responses were systematically coded and subsequently entered into Microsoft Excel, with verification procedures undertaken to ensure data accuracy. Data deemed incomplete or inconsistent were excluded prior to analysis. Statistical procedures were executed utilizing IBM SPSS Statistics (Version 25.0; IBM Corp., Armonk, NY, USA). Descriptive statistics, including frequencies, percentages, means, and standard deviations, were employed to summarize participant characteristics and knowledge, attitude, and practice (KAP) outcomes. The relationships between categorical variables, such as professional level and KAP outcomes, were assessed using Pearson's chi-square test, appropriate for nominal and ordinal data. A two-tailed p-value of less than 0.05 was considered statistically significant, with p-values less than 0.001 indicating high significance. The results were presented both narratively and in tabular formats, with visual representations generated in Microsoft Excel.

Results

The survey encompassed 204 dental professionals and students from varied academic and clinical backgrounds. The findings are organized into four domains: demographic and professional characteristics, knowledge, attitudes, and practices (KAP) of digital prosthodontics, as well as their correlations with professional level. Percentages depict the distribution of responses, and statistically significant relationships ($p < 0.05$) are highlighted.

The study population was predominantly young (under 25 years, 51%), with a higher proportion of females (53.4%) compared to males. The majority had limited clinical experience (less than 5 years, 59.1%). More than half (55%) held a basic dental degree, while approximately 10% possessed a PhD. General dentists represented the largest specialty group (45.1%), and universities and academic institutions served as the primary practice setting (53.9%; Figure 1).

https://doi.org/10.11138/oi.v18i1.219

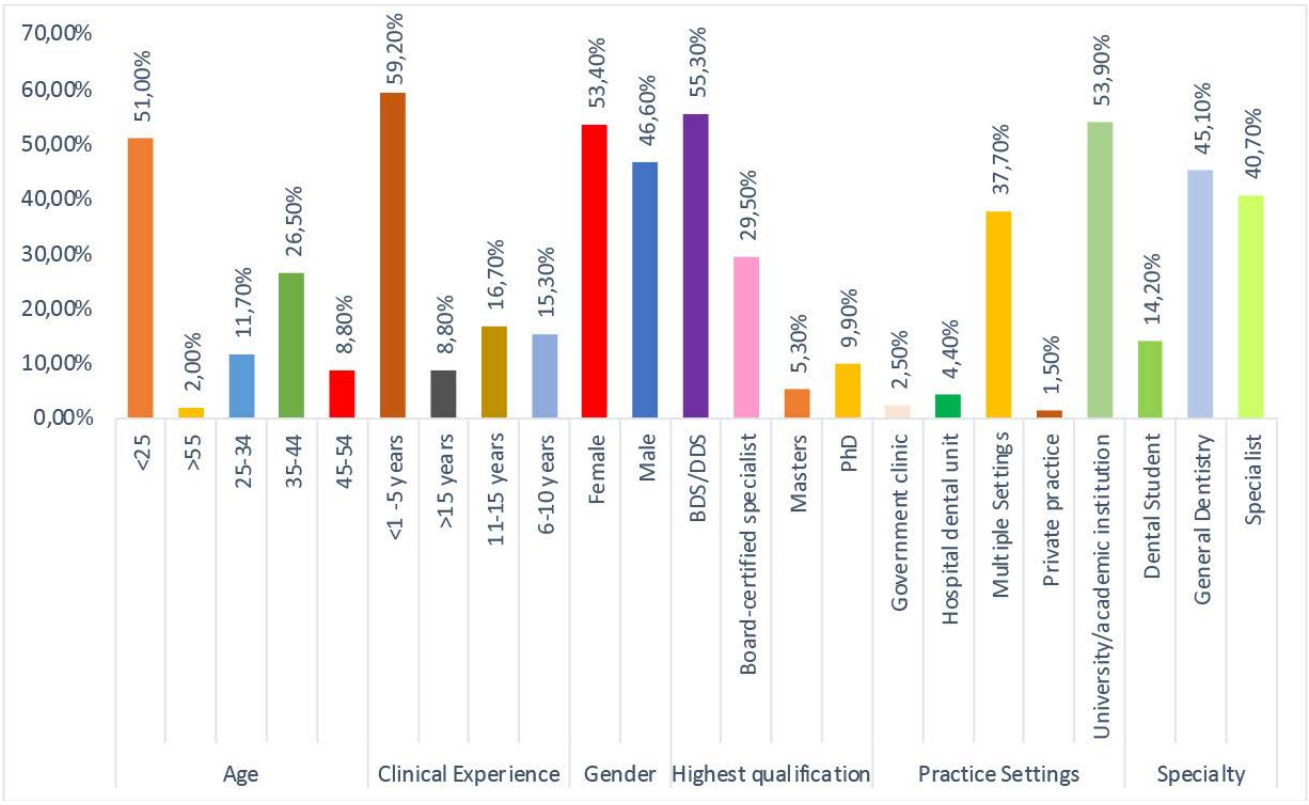

Figure 1. Distribution of demographic and professional characteristics of participants

Although 57.8% recognized the term 'digital prosthodontics', nearly half exhibited insufficient knowledge. Familiarity with specific technologies, such as CAD/CAM (19.1%) and IOSs (13.7%), was moderate, while awareness of virtual articulators was minimal (8.8%). The primary sources of knowledge were undergraduate training (24.5%) and self-study or colleagues (22.5%; Table 1).

Table 1. Awareness of digital prosthodontics and sources of information.

Questions	Answers	n	%
Are you aware of the term digital prosthodontics?	No	86	42.2%
	Yes	118	57.8%
Which of the following digital technologies are you aware of in prosthodontics?	3D printing/additive manufacturing	27	13.2%
	CAD/CAM systems	39	19.1%
	CBCT-based implant planning	28	13.7%
	Digital dentures	21	10.3%
	Digital occlusal analysis	21	10.3%
	Guided surgery systems	22	10.8%
	Intraoral scanners (IOS)	28	13.7%
	Virtual articulators (simulate jaw movements)	18	8.8%
Do you have any knowledge of digital prosthodontic technologies?	No, I do not have knowledge	93	45.6%
	Yes, I have some knowledge	111	54.4%

https://doi.org/10.11138/oi.v18i1.219

Questions	Answers	n	%
Where did you gain most of your knowledge about digital prosthodontics?	Continuing education (workshops/conferences)	34	16.7%
	I do not know	10	5%
	In SIDC Riyadh	5	2.5%
	Online courses/social media	35	17.2%
	Postgraduate studies	24	11.8%
	Self-study/colleagues	46	22.5%
	Undergraduate training	50	24.5%

Specialists significantly exceeded general dentists in all awareness metrics ($p < 0.001$ for the majority of comparisons). For instance, 76 specialists compared to 42 general dentists were familiar with the term 'digital prosthodontics' (see Table 2).

Table 2. Association between professional level and awareness of digital prosthodontics (Chi-square test)

Questions	Answers	General Dentist (n=121)	Specialist (n=83)	X[2]	p
Are you aware of the term digital prosthodontics?	No	79	7	65.3	**< 0.001***
	Yes	42	76		
Which of the following digital technologies are you aware of in prosthodontics?	3D printing/additive manufacturing	14	13	24.3	**0.001***
	CAD/CAM systems	14	25	0.529	
	CBCT-based implant planning	18	10	0.324	
	Digital dentures	16	5	0.354	
	Digital occlusal analysis	8	13	0.289	
	Guided surgery systems	17	5	0.584	
	Intraoral scanners (IOS)	19	9	0.307	
	Virtual articulators (simulate jaw movements)	15	3	0.331	
Do you have any knowledge of digital prosthodontic technologies?	No, I don't have knowledge	77	16	39.1	**< 0.001***
	Yes, I have some knowledge	44	67		
Where did you gain most of your knowledge about digital prosthodontics?	Continuing education (workshops/conferences)	5	29	122	**< 0.001***
	I don't know	10	0		
	In SIDC Riyadh	5	0		
	Online courses/social media	13	22		
	Postgraduate studies	0	24		
	Self-study/colleagues	41	5		
	Undergraduate training	47	3		

**statistically significant*

Understanding of comprehensive digital workflows was inconsistent: 30.6% recognized 3D printing/milling as a crucial element, whereas 18% acknowledged a lack of knowledge regarding the workflow. Porcelain veneers (39.7%) and complete dentures (23.1%) were the most recognized CAD/CAM-fabricable prostheses. The most valued benefit of IOSs is the reduction of chairside time by 53.1%. However, a significant proportion of respondents expressed uncertainty regarding applications, such as virtual articulators (38.7% indicated "don't know") and implant planning tools (44.1% indicated "don't know"; Table 3).

https://doi.org/10.11138/oi.v18i1.219

Table 3. Knowledge of digital prosthodontic workflows, applications, and benefits.

Questions	Answers	Counts	% of Total
Which of the following technologies are components of a complete digital prosthodontic workflow?	3D printing or milling machine	34	30.6%
	Articulating paper	10	9.0%
	CAD software	21	18.9%
	I do not know	20	18.0%
	Intraoral scanner (IOS)	26	23.4%
Which of the following prostheses can be fabricated using CAD/CAM systems?	Complete dentures	46	23.1%
	I do not know	33	16.6%
	Metal-ceramic crowns	8	4.0%
	Porcelain veneers	79	39.7%
	Surgical guides	33	16.66%
What are the main advantages of using intraoral scanners compared to conventional impressions?	I do not know	13	7.3%
	Improved patient comfort	36	20.1%
	Improved soft tissue recording	14	7.8%
	Real-time visualization	21	11.7%
	Reduced chairside time	95	53.1%
What are typical clinical applications of 3D printing in prosthodontics?	Fabrication of full metal crowns	5	2.6%
	Fabrication of implant surgical guides	91	47.9%
	I do not know	45	23.7%
	Printing custom trays	9	4.7%
	Printing of diagnostic wax-ups	18	9.5%
	Provisional restorations	14	7.4%
	Real-time occlusal correction	8	4.2%
What is the role of virtual articulators in prosthodontics?	I do not know	72	38.7%
	Predicting occlusal interferences	32	17.2%
	Recording vertical dimension	5	2.7%
	Simulating mandibular movements	77	41.4%
Which digital tools are most commonly used in implant planning and placement workflows?	CBCT imaging	89	43.6%
	Guided surgery software	10	4.9%
	I do not know	90	44.1%
	IOS for scanning edentulous arches	15	7.4%
What are the main benefits of digital denture workflows compared to conventional methods?	Accurate recording of soft tissues in function	47	23.0%
	Better reproducibility	40	19.6%
	Fewer clinical visits	53	26.0%
	Fully automated occlusal design	5	2.5%
	I do not know	40	19.6%
	Real-time occlusion tracking	19	9.3%

Experts exhibited markedly higher levels of knowledge, particularly concerning the benefits of IOSs and the applications of 3D printing, with numerous correlations attaining strong statistical significance ($p < 0.001$). This highlights the disparity in expertise between general practitioners and specialists (see Table 4).

https://doi.org/10.11138/oi.v18i1.219

Table 4. Association between professional level and knowledge of digital prosthodontics (Chi-square test)

Questions	Answers	General Dentist	Specialist	X[2]	p
Which of the following digital technologies are you aware of in prosthodontics?	3D printing/additive manufacturing	14	13	24.3	**0.001***
	CAD/CAM systems	14	25		
	CBCT-based implant planning	18	10		
	Digital dentures	16	5		
	Digital occlusal analysis	8	13		
	Guided surgery systems	17	5		
	Intraoral scanners (IOS)	19	9		
	Virtual articulators (simulate jaw movements)	15	3		
Which of the following prostheses can be fabricated using CAD/CAM systems?	Complete dentures	15	31	38.1	**< 0.001***
	I dont know	29	4		
	Metal-ceramic crowns	0	8		
	Porcelain veneers	53	26		
	Surgical guides	19	14		
What are the main advantages of using intraoral scanners compared to conventional impressions?	I dont know	13	0	85.2	**< 0.001***
	Improved patient comfort	4	32		
	Improved soft tissue recording	9	5		
	Real-time visualization	0	21		
	Reduced chairside time	74	21		
What are typical clinical applications of 3D printing in prosthodontics?	Fabrication of full metal crowns	0	5	43.4	**< 0.001***
	Fabrication of implant surgical guides	47	44		
	I don't know	37	8		
	Printing custom trays	0	9		
	Printing of diagnostic wax-ups	8	10		
	Provisional restorations	14	0		
	Real-time occlusal correction	5	3		
What is the role of virtual articulators in prosthodontics?	I dont know	47	25	10.1	**0.017***
	Predicting occlusal interferences	15	17		
	Recording vertical dimension	5	0		
	Simulating mandibular movements	36	41		
Which digital tools are most commonly used in implant planning and placement workflows?	CBCT imaging	41	48	37.6	**< 0.001***
	Guided surgery software	0	10		
	I dont know	65	25		
	IOS for scanning edentulous arches	15	0		
What are the main benefits of digital denture workflows compared to conventional methods?	Accurate recording of soft tissues in function	34	13	16.3	**0.006***
	Better reproducibility	25	15		
	Fewer clinical visits	31	22		
	Fully automated occlusal design	5	0		
	I dont know	21	19		
	Real-time occlusion tracking	5	14		

**statistically significant*

Despite a reasonable level of awareness, only one-quarter (25.5%) of practitioners actually utilized digital prosthodontic

https://doi.org/10.11138/oi.v18i1.219

technologies. Intraoral scans (IOSs) were the most prevalent (48.5%), followed by Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) at 27%. The primary indication for use was crown and bridge restorations (63.7%). The majority of adopters had between 1 to 3 years of experience and rated their confidence as moderate, with 50% assigning a score of 3. The main barriers identified included high initial costs (23%) and inadequate training (16.7%). Notably, 79.9% expressed a preference for structured training programs, and 72.1% supported the integration of such technologies into the curriculum (Table 5).

Table 5. Practice of digital prosthodontics and perceived barriers.

Questions	Answers	n	%
Do you use any digital prosthodontic technologies in your clinical practice?	No	152	74.5%
	Yes	52	25.5%
Which of these technologies do you currently use in your clinical practice?	3D printing	31	15.2%
	CAD/CAM	55	27.0%
	IOS	99	48.5%
	Virtual articulator	19	9.3%
If using any digital tools, for which indications?	Crown/bridge restorations	130	63.7%
	Endodontics guided	9	4.4%
	Implant-supported prostheses	28	13.7%
	Surgical guide fabrication	37	18.1%
How long have you been using digital tools in your practice?	1-3 years	131	64.2%
	4-6 years	43	21.1%
	>6 years	30	14.7%
Please rate your confidence in using digital tools in prosthodontics	1	15	7.4%
	2	18	8.8%
	3	102	50.0%
	4	64	31.4%
	5	5	2.5%
What are the main barriers you face in adopting digital prosthodontics?	High initial cost	47	23.0%
	I did not use it	5	2.5%
	Lack of institutional support	24	11.8%
	Lack of training/skills	34	16.7%
	Resistance from colleagues	16	7.8%
	Technology is too complex	13	6.4%
	Lack of awareness about benefits	30	14.7%
	No perceived advantage over traditional techniques	7	3.4%
	Incompatibility with current workflows	15	7.4%
	Time constraints	9	4.4%
	Unemployed	4	2.0%
Would you be interested in receiving structured training in digital prosthodontic tools?	No	6	2.9%
	Not sure	35	17.2%
	Yes	163	79.9%

https://doi.org/10.11138/oi.v18i1.219

Questions	Answers	n	%
Preferred method of training	In-person workshops	87	42.6%
	Industry training sessions	5	2.5%
	None	19	9.3%
	Online courses	25	12.3%
	Self-paced learning/video tutorials	19	9.3%
	University-based CPD programs	49	24.0%
Do you believe digital prosthodontics should be fully integrated into dental curricula?	No	5	2.5%
	Not sure	52	25.5%
	Yes	147	72.1%

Experts demonstrated markedly increased utilization, extensive experience, and heightened confidence in digital tools ($p < 0.001$ for key items). This data indicates that specialization facilitates the practical implementation of digital prosthodontics (Table 6).

Table 6. Association between professional level and practice of digital prosthodontics (Chi-square test).

Questions	Answers	General Dentist	Specialist	X[2]	p
Do you use any digital prosthodontic technologies in your clinical practice?	No	79	7	102	**< 0.001***
	Yes	42	76		
Which of these technologies do you currently use in your clinical practice?	3D printing	10	21	12.5	**0.006***
	CAD/CAM	37	18		
	IOS	60	39		
	Virtual articulator	14	5		
If using any digital tools, for which indications?	Crown/bridge restorations	85	45	15.6	**0.001***
	Endodontics guided	0	9		
	Implant-supported prostheses	15	13		
	Surgical guide fabrication	21	16		
How long have you been using digital tools in your practice?	1-3 years	88	43	9.86	**0.007***
	4-6 years	18	25		
	>6 years	15	15		
Please rate your confidence in using digital tools in prosthodontics	1	5	10	43.0	**< 0.001***
	2	10	8		
	3	82	20		
	4	24	40		
	5	0	5		
What are the main barriers you face in adopting digital prosthodontics?	High initial cost	20	27	15.8	**0.106**
	I did not use it	5	0		
	Lack of institutional support	16	8		
	Lack of training/skills	24	10		
	Resistance from colleagues	11	5		
	Technology is too complex	7	6		
	Lack of awareness about benefits	18	12		

https://doi.org/10.11138/oi.v18i1.219

Questions	Answers	General Dentist	Specialist	X[2]	p
	No perceived advantage over traditional techniques	4	3		
	Incompatibility with current workflows	7	8		
	Time constraints	5	4		
	Unemployed	4	0		
Would you be interested in receiving structured training in digital prosthodontic tools?	No	6	0	6.18	**0.046***
	Not sure	24	11		
	Yes	91	72		
Preferred method of training	In-person workshops	47	40	6.12	0.295
	Industry training sessions	5	0		
	None	11	8		
	Online courses	15	10		
	Self-paced learning/video tutorials	10	9		
	University-based CPD programs	33	16		
Do you believe digital prosthodontics should be fully integrated into dental curricula?	No	5	0	15.8	**< 0.001***
	Not sure	41	11		
	Yes	75	72		

**statistically significant*

The survey indicates a youthful and academically inclined dental workforce with moderate awareness; however, practical application remains limited in digital prosthodontics. Experts consistently exhibit improved Knowledge, Attitudes, and Practices (KAP), underscoring the importance of postgraduate education. The primary challenges include high initial costs and insufficient formal training. Broad enthusiasm for structured training and curricular integration suggests a clear pathway for the development of digital prosthodontics within dental education and practice.

Discussion

This study offers novel insights into the knowledge, awareness, and adoption of digital prosthodontics among dental practitioners in Saudi Arabia, contextualized within international evidence. The findings suggest a predominantly youthful and academically inclined workforce with substantial familiarity with digital technologies and a strong eagerness to learn. Nevertheless, clinical adoption remains primarily limited to specialists. These results are consistent with prior Saudi surveys demonstrating high acceptance but limited practice, usually confined to academic or tertiary settings. [16,18] Similar gaps in adoption awareness have been observed globally; for instance, Indian dentists reported an overall adoption rate of 42.5%, mainly for scanners and crowns, with advanced tools infrequently utilized. [11] In Germany, clinics averaged 7.5 digital devices; however, widespread adoption was uncommon and closely linked to available resources and scope of practice. [25] Such parallels suggest that Saudi dentists are equally aware as their international counterparts but encounter persistent structural and educational challenges that hinder practical implementation.

Awareness and Barriers to Adoption

Levels of awareness across various technologies exhibited significant variability. A moderate proportion of respondents acknowledged familiarity with CAD/CAM systems and IOSs. However, only a limited number of individuals were acquainted with advanced technologies, such as virtual articulators and implant planning tools, and nearly one-fifth expressed uncertainty regarding digital workflows. This trend aligns with extensive research findings at both national and international levels. Studies conducted in Saudi Arabia concerning oral and maxillofacial surgery similarly indicated a lack of awareness regarding advanced computer-assisted technologies. Similarly, Sabalic and Schoener (2017) identified limited familiarity with VR-based technologies among both students and practitioners. [26-27] Collectively, these findings suggest that while clinicians demonstrate confidence in fundamental tools, advanced applications such as digital dentures, virtual articulators, and AI-assisted planning remain underutilized. Despite moderate awareness, only 25% of practitioners in Saudi Arabia have integrated digital prosthodontics into their daily practice, primarily utilizing IOSs. This observation is consistent with data from India indicating that 87% of adopters used scanners, whereas only 1.2% employed chairside milling. In Germany,

https://doi.org/10.11138/oi.v18i1.219

56.5% utilized 3D radiography, and 48% employed CAD/CAM systems, whereas fewer than 20% adopted AI or cloud-based systems.

Global trends demonstrate that entry-level technologies with clear clinical utility tend to adopt more swiftly, whereas more advanced, capital-intensive systems experience slower integration. The obstacles identified in this study—namely, equipment costs, insufficient training, workflow integration challenges, and lack of institutional support—align with previous findings from Saudi Arabia and international observations. In Riyadh, only 27.2% of dentists had access to chairside CAD/CAM, despite 81% endorsing its quality. In 2024, [17,19] and Alqahtani et al. recognized similar financial and infrastructural barriers. Schnitzler and Bohnet-Joschko (2025) found that German group practices employed an average of 11 devices, whereas solo practices used only 5, thereby highlighting structural disparities in access [25]. Without strategic investment and policy incentives, it is likely that disparities within Saudi dentistry will continue.

Specialist vs. General Dentist

Specialists demonstrated significantly superior knowledge, awareness, and adoption compared to general dentists, reflecting greater exposure to complex cases, advanced training, and resource availability. Such findings have been corroborated both nationally and internationally, [14,18] and Yadav et al. (2025) [28] reported a substantial level of preparedness among specialists across various disciplines. In Egypt, postgraduate trainees and faculty members exhibited higher proficiency, whereas general practitioners primarily relied on brief workshops or self-directed learning. A Dutch survey revealed that "high technology users" tended to be younger, worked longer hours, and operated in larger clinics with higher patient volumes, whereas "low users" were generally older and practiced in smaller settings. [29] Overall, these findings suggest that adoption is stratified not only by specialization but also by practice environment and workload. Addressing this disparity requires curricular reform, continuous professional development, and improved access to equipment in community-based settings.

Educational and Clinical Impacts

A significant inclination among Saudi practitioners to pursue formal training and support the integration of curricula highlights a notable opportunity for reform. Over 70% of participants support incorporating digital tools into undergraduate curricula. Adoption predictions based on training indicate that, in India, 52.9% of adopters received formal instruction, compared to only 8.7% of non-users. Structured exposure to digital techniques enhances confidence and performance, whereas fragmented curricula present obstacles. In Saudi universities, the integration of digital dentistry into academic programs varies considerably among institutions. A structured framework that includes the use of scanners during preclinical years, CAD/CAM and 3D printing during clinical phases, and advanced tools in postgraduate studies could reduce steep learning curves and better prepare graduates for professional practice.

Clinically, restricted adoption has tangible consequences. Digital impressions and CAD/CAM restorations demonstrate accuracy comparable to traditional methods, thereby reducing chairside time and enhancing patient comfort [34,36]. Digital denture workflows improve reproducibility and diminish the need for adjustments. Positive satisfaction scores from adopters in the Netherlands (mean 3.4–4.4/5) suggest that, once integrated, digital technologies enhance efficiency and the clinical experience. In the absence of comprehensive integration, patients may not fully realize these benefits, and practitioners may not meet global standards. Incremental investment in digital technologies, along with training and centralized resource centers or laboratories, may improve accessibility and reduce costs.

Strengths, Limitations, and Future Directions

This study represents one of the initial evaluations of knowledge, attitudes, and practices concerning digital prosthodontics in Saudi Arabia, emphasizing differences between general dentists and specialists. The survey instrument was tested and validated, confirming its reliability. Limitations include potential selection bias arising from convenience sampling, voluntary participation, reliance on self-reported data, and a cross-sectional design that captures only a single time point. The sample exhibited bias towards academic practitioners, which may restrict the generalizability of the findings. Future research should assess the impact of curricular reforms, continuing education programs, and cost-sharing initiatives on adoption. Objective skill-based assessments and longitudinal studies are recommended to provide robust evidence regarding the effects of training and infrastructure on clinical integration. Evaluating the cost-effectiveness of digital workflows within Saudi practice models will further inform resource allocation strategies.

Conclusion

Dental practitioners in Saudi Arabia demonstrate a moderate level of understanding regarding digital prosthodontics. Nonetheless, its routine application in clinical settings remains confined to specialists. The principal barriers include financial

https://doi.org/10.11138/oi.v18i1.219

limitations and the absence of structured training programs. Nevertheless, a keen interest in curricular and continuing education reforms offers a promising opportunity to bridge this gap. Emphasizing educational reforms, facilitating accessible training, and implementing cost-sharing strategies will serve to improve patient care and synchronize Saudi prosthodontic practices with national digital health initiatives and international standards.

References

1. Elmarakby A, Alrashed A, Zahr A, Alanazi F, Alazmi G, Abulsaud H, Alsulami R, Jafar S, Albalawi S, AlRosini S, Alenazi S. The transformative impact of digital technologies on modern dentistry: a narrative review of the applications and benefits. J Healthcare Scien. 2025;5:24-30. DOI:10.52533/JOHS.2025.50103. https://doi.org/10.52533/JOHS.2025.50103
2. The Glossary of Prosthodontic Terms 2023: Tenth Edition. J Prosthet Dent. 2023;130(4 Suppl 1):e1-e3. DOI:10.1016/j.prosdent.2023.03.003. https://doi.org/10.1016/j.prosdent.2023.03.003
3. Abdulkarim LI, Alharamlah FSS, Abubshait RM, Alotaibi DA, Abouonq AO. Impact of digital workflow integration on fixed prosthodontics: a review of advances and clinical outcomes. Cureus. 2024;16[10]:e72286. DOI:10.7759/cureus.72286. https://doi.org/10.7759/cureus.72286
4. Bernauer SA, Zitzmann NU, Joda T. The complete digital workflow in fixed prosthodontics updated: a systematic review. Healthcare (Basel). 2023;11[5]:679. DOI:10.3390/healthcare11050679. https://doi.org/10.3390/healthcare11050679
5. Rezaie F, Farshbaf M, Dahri M, Masjedi M, Maleki R, Amini F, Wirth J, Moharamzadeh K, Weber FE, Tayebi L. 3D printing of dental prostheses: current and emerging applications. J Compos Sci. 2023;7[2]:80. DOI:10.3390/jcs7020080. https://doi.org/10.3390/jcs7020080
6. Chen CS, Hsu H, Kuo YW, Kuo HY, Wang CW. Digital workflow and guided surgery in implant therapy-literature review and practical tips to optimize precision. Clin Implant Dent Relat Res. 2025;27[3]:e70038. DOI:10.1111/cid.70038. https://doi.org/10.1111/cid.70038
7. Doshi KN, Sathe S, Dubey SA, Bhoyar A, Dhamande M, Jaiswal T. A comprehensive review on virtual articulators. Cureus. 2024;16[1]:e52554. DOI:10.7759/cureus.52554. https://doi.org/10.7759/cureus.52554
8. Bessadet M, et al. Time efficiency and cost analysis between digital and conventional workflows for the fabrication of fixed dental prostheses: a systematic review. J Prosthet Dent. 2025;133[1]:71-84. DOI:10.1016/j.prosdent.2024.01.003. https://doi.org/10.1016/j.prosdent.2024.01.003
9. Soni M, Soni P, Soni P, Chokhandre S, Moni M, Gupta S. The role of digital workflow in customizing the prosthetic solutions: a literature review. J Pharm Bioallied Sci. 2025;17(Suppl 2):S1095-S1097. DOI:10.4103/jpbs.jpbs_1700_24. https://doi.org/10.4103/jpbs.jpbs_1700_24
10. Hall MA, Karawia I, Mahmoud AZ, et al. Knowledge, awareness, and perception of digital dentistry among Egyptian dentists: a cross-sectional study. BMC Oral Health. 2023;23:963. DOI:10.1186/s12903-023-03698-1. https://doi.org/10.1186/s12903-023-03698-1
11. Usman MJ, Latha N, Saraswathy A, Makkadan Thachanath H. Integration of three-dimensional scanning and computer-aided design/computer-aided manufacturing (CAD/CAM) technology in routine prosthodontic practice: a cross-sectional study in Kerala. Cureus. 2024;16[12]:e76409. DOI:10.7759/cureus.76409. https://doi.org/10.7759/cureus.76409
12. Sri H, Maiti S, Sasanka K. Knowledge, attitude, and practice of digital dentures among dentists. J Adv Pharm Technol Res. 2022;13(Suppl 2):S519-S524. DOI:10.4103/japtr.japtr_186_22. https://doi.org/10.4103/japtr.japtr_186_22
13. Castelin C. Clinician perspectives on current implementation of digitally fabricated complete dentures: a survey of prosthodontists. 2020. DOI:10.17615/5ac9-y041.
14. Alnafaiy SM, Alyousef H, Aljabr R, et al. Digital technology implementation in prosthodontics postgraduate programs in Saudi Arabia: a multi-institutional survey of program directors. BMC Oral Health. 2024;24:1136. DOI:10.1186/s12903-024-04908-0. https://doi.org/10.1186/s12903-024-04908-0
15. Suleiman AK, Ming LC. Transforming healthcare: Saudi Arabia's vision 2030 healthcare model. J Pharm Policy Pract. 2025;18[1]:2449051. DOI:10.1080/20523211.2024.2449051. https://doi.org/10.1080/20523211.2024.2449051
16. Nassani MZ, Ibraheem S, Shamsy E, Darwish M, Faden A, Kujan O. A survey of dentists' perception of chair-side CAD/CAM technology. Healthcare (Basel). 2021;9[1]:68. DOI:10.3390/healthcare9010068. https://doi.org/10.3390/healthcare9010068
17. Alanazi KK, Alzaid AA, Alotaibi A, et al. Assessment of knowledge and practices of additive manufacturing in dentistry among university

 https://doi.org/10.11138/oi.v18i1.219

teaching faculty in Saudi Arabia. BMC Oral Health. 2024;24:271. DOI:10.1186/s12903-024-04037-8.
https://doi.org/10.1186/s12903-024-04037-8

18. Radwan H, Alsharif A, Alsharif M, Aloufi M, Alshammari B. Digital technologies in dentistry in Saudi Arabia: perceptions, practices and challenges. Digit Health. 2023;9:20552076231197095. DOI:10.1177/20552076231197095.
https://doi.org/10.1177/20552076231197095

19. Alqahtani SM, Chaturvedi S, Alahmari MA, Alaleyani AM, Alqahtani AA, Sahal AA, Salem M. Digital impression (intraoral scanners) and factors affecting its accuracy - an insight into knowledge and awareness amongst graduates, and clinical practitioners. BMC Oral Health. 2024;24[1]:1323. DOI:10.1186/s12903-024-05075-y.
https://doi.org/10.1186/s12903-024-05075-y

20. Von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Lancet. 2007;370(9596):1453-7.DOI: 10.1016/S0140-6736(07)61602-X
https://doi.org/10.1016/S0140-6736(07)61602-X

21. World Medical Association. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. JAMA. 2013;310(20):2191-4.DOI: 10.1001/jama.2013.281053
https://doi.org/10.1001/jama.2013.281053

22. Alqahtani HM, Alshehri MK. Demographic insights into the periodontology workforce in Saudi Arabia: a descriptive study. Saudi Dent J. 2024;36(5):718-21.DOI: 10.1016/j.sdentj.2024.02.020
https://doi.org/10.1016/j.sdentj.2024.02.020

23. Polit DF, Beck CT. The content validity index: are you sure you know what's being reported? Critique and recommendations. Res Nurs Health. 2006;29(5):489-97. DOI: 10.1002/nur.20147
https://doi.org/10.1002/nur.20147

24. Taherdoost H. Validity and reliability of the research instrument; how to test the validation of a questionnaire/survey in research. Int J Acad Res Manag (IJARM). 2016;5. DOI: 10.2139/ssrn.3205040
https://doi.org/10.2139/ssrn.3205040

25. Schnitzler C, Bohnet-Joschko S. Technology readiness drives digital adoption in dentistry: insights from a cross-sectional study. InHealthcare. 2025;13(10):1155.DOI: 10.3390/healthcare13101155
https://doi.org/10.3390/healthcare13101155

26. Alyami DA, Alrasheedi AN, Alrashidy NN, Alrashidy ANA. Dentists' knowledge, usage and barriers to computer-assisted technologies in oral and maxillofacial surgery: a cross-sectional study in Saudi Arabia. J Pioneering Med Sci. 2025;14:98-105. DOI:10.47310/jpms2025140413
https://doi.org/10.47310/jpms2025140413

27. Sabalic M, Schoener JD. Virtual reality-based technologies in dental medicine: knowledge, attitudes and practice among students and practitioners. Technol Knowl Learn. 2017;22(2):199-207. DOI: 10.1007/s10758-017-9305-4.
https://doi.org/10.1007/s10758-017-9305-4

28. Yadav R, Malhotra H, Mittal N, Pal A, Misra A. Readiness for digital dentistry in practice: a cross-specialty assessment of awareness, acceptance, and barriers. J Clin Insights Res Dent. 2025;1(2):72-5. DOI:10.5005/jcird-11034-0022.
https://doi.org/10.5005/jcird-11034-0022

29. Van Der Zande MM, Gorter RC, Aartman IHA, Wismeijer D. Adoption and use of digital technologies among general dental practitioners in the Netherlands. PLoS One. 2015;10:e0120725. DOI: 10.1371/journal.pone.0120725
https://doi.org/10.1371/journal.pone.0120725

30. Ciocan LT, Pantea M, Vasilescu VG, Țâncu AMC, Sfeatcu R, Didilescu AC, Ripszky A, Popa A, Pițuru SM, Imre M. Evaluation of undergraduate dental students' opinions on the use of digital versus conventional design in prosthodontics. Dent J. 2025;13(6):242. DOI:10.3390/dj13060242.
https://doi.org/10.3390/dj13060242

31. Pham LT, Doan TM, Tran TT, Pham VK. Effectiveness of a digital educational system on the learners' performance in preclinical fixed prosthodontic training. BDJ Open. 2025;11(1):54. DOI:10.1038/s41405-025-00344-6.
https://doi.org/10.1038/s41405-025-00344-6

32. Ohyama H, Duong ML, Yancoskie AE, Smiley AB, Syed AZ, Reddy MS, Bencharit S. Challenges and opportunities in implementing digital technology in dental curriculum: a review and perspective. Cureus. 2025;17(4):e83272. DOI:10.7759/cureus.83272.
https://doi.org/10.7759/cureus.83272

33. Alfallaj HA, Afrashtehfar KI, Asiri AK, Almasoud FS, Alnaqa GH, Al-Angari NS. The status of digital dental technology implementation in the Saudi dental schools' curriculum: a national cross-sectional survey for healthcare digitization. Int J Environ Res Public Health. 2022;20(1):321. DOI:10.3390/ijerph20010321.
https://doi.org/10.3390/ijerph20010321

34. Ahmed S, Hawsah A, Rustom R, Alamri A, Althomairy S, Alenezi M, Shaker S, Alrawsaa F, Althumairy A, Alteraigi A. Digital impressions

 https://doi.org/10.11138/oi.v18i1.219

versus conventional impressions in prosthodontics: a systematic review. Cureus. 2024;16(1):e51537. DOI:10.7759/cureus.51537. https://doi.org/10.7759/cureus.51537

35. El Osta N, Bessadet M, Drancourt N, Batisse C. Time efficiency and cost of fabricating removable complete dentures using digital, hybrid, and conventional workflows: a systematic review. J Prosthet Dent. 2025;133(5):1194-208. DOI:10.1016/j.prosdent.2024.10.008. https://doi.org/10.1016/j.prosdent.2024.10.008
36. Zandinejad A, Floriani F, Lin WS, Naimi-Akbar A. Clinical outcomes of milled, 3D-printed, and conventional complete dentures in edentulous patients: a systematic review and meta-analysis. J Prosthodont. 2024;33(8):736-47. DOI:10.1111/jopr.13859. https://doi.org/10.1111/jopr.13859
37. González A, Monzón M, Paz R, Suárez L, García J, Bordón P, Ortega Z. The evolution of digital technologies in dentistry: latest updates, challenges and barriers. Open Res Eur. 2025;5:276. DOI:10.12688/openreseurope.21242.1. https://doi.org/10.12688/openreseurope.21242.1

https://doi.org/10.11138/oi.v18i1.219

Knowledge, Awareness, and Practices of Digital Prosthodontic Technologies Among Dental Professionals in Saudi Arabia

Section A: Demographic and Professional Background

1. Age:
☐ <25 ☐ 25–34 ☐ 35–44 ☐ 45–54 ☐ ≥55

2. Gender:
☐ Male ☐ Female ☐ Prefer not to say

3. Years of clinical experience:
☐ <2 years ☐ 2–5 ☐ 6–10 ☐ 11–15 ☐ >15

4. Highest qualification:
☐ BDS/DDS ☐ Master's ☐ PhD ☐ Board-certified specialist

5. Practice setting (select all that apply):
☐ Private practice
☐ Government clinic
☐ University/academic institution
☐ Hospital dental unit

6. Specialty:
☐ Interns ☐ General Dentist ☐ Prosthodontist ☐ Other (please specify): _____

Section B: Awareness of Digital Prosthodontic Tool

7. Are you aware of the term "digital prosthodontics"?
☐ Yes ☐ No

11. Which of the following digital technologies are you aware of in prosthodontics? *(Select all that apply)*
☐ Intraoral scanners (IOS)
☐ CAD/CAM systems
☐ 3D printing/additive manufacturing
☐ Digital dentures
☐ Virtual articulators
☐ CBCT-based implant planning
☐ Guided surgery systems
☐ Digital occlusal analysis
☐ Other (please specify): _____
☐ **I am not aware of any digital prosthodontic technologies**

8. Where did you gain most of your knowledge about digital prosthodontics?
☐ Undergraduate training
☐ Postgraduate studies
☐ Continuing education (workshops/conferences)
☐ Online courses/social media
☐ Self-study/colleagues
☐ Industry/company training
☐ **Not applicable**

Section C: Knowledge Assessment (Objective)

Choose all correct answers. Multiple responses may apply.

Q10. Which of the following technologies are components of a complete digital prosthodontic workflow?
☐ Intraoral scanner (IOS) ✓
☐ Alginate impression
☐ CAD software✓
☐ Articulating paper
☐ 3D printing or milling machine ✓
☐ **I don't know**

https://doi.org/10.11138/oi.v18i1.219

Q11. Which of the following prostheses can be fabricated using CAD/CAM systems?

☐ Metal-ceramic crowns ✓
☐ Complete dentures ✓
☐ Porcelain veneers ✓
☐ Surgical guides ✓
☐ Space maintainers
☐ **I don't know**

Q12. What are the main advantages of using intraoral scanners compared to conventional impressions?

☐ Reduced chairside time ✓
☐ Improved soft tissue recording
☐ Real-time visualization ✓
☐ Increased radiation exposure
☐ Improved patient comfort ✓
☐ Requires no operator training
☐ **I don't know**

Q13. What are typical clinical applications of 3D printing in prosthodontics?

☐ Provisional restorations ✓
☐ Fabrication of implant surgical guides ✓
☐ Fabrication of full metal crowns
☐ Printing of diagnostic wax-ups ✓
☐ Printing custom trays ✓
☐ Real-time occlusal correction
☐ **I don't know**

Q14. What is the role of virtual articulators in prosthodontics?

☐ Recording vertical dimension
☐ Simulating mandibular movements ✓
☐ Designing removable partial dentures
☐ Predicting occlusal interferences ✓
☐ Capturing shade selection automatically
☐ I don't know

Q15. Which digital tools are most commonly used in implant planning and placement workflows?

☐ CBCT imaging ✓
☐ Guided surgery software ✓
☐ CAD for implant bar design ✓
☐ IOS for scanning edentulous arches ✓
☐ Digital radiography (2D)
☐ **I don't know**

Q16. What are the main benefits of digital denture workflows compared to conventional methods?

☐ Fewer clinical visits ✓
☐ Real-time occlusion tracking
☐ Better reproducibility ✓
☐ Accurate recording of soft tissues in function
☐ Fully automated occlusal design
☐ **I don't know**

Section D: Clinical Practice and Usage and Future Adoption

12. Which of these technologies do you currently use in your clinical practice? *(Select all that apply)*

☐ IOS ☐ CAD/CAM ☐ 3D printing
☐ Virtual articulator ☐ Digital denture workflows

https://doi.org/10.11138/oi.v18i1.219

☐ CBCT-guided implant planning ☐ Digital occlusal analysis

☐ **I do not use any digital prosthodontic technologies**

13. If using any digital tools, for which indications? *(Select all that apply)*

☐ Crown/bridge restorations
☐ Complete dentures
☐ Implant-supported prostheses
☐ Surgical guide fabrication
☐ Temporaries/provisional prostheses
☐ Occlusal adjustments
☐ Other (please specify): _____

14. How long have you been using digital tools in your practice?

☐ Not using yet
☐ <1 year ☐ 1–3 years ☐ 4–6 years ☐ >6 years

15. What are the main barriers you face in adopting digital prosthodontics? *(Select all that apply)*

☐ High initial cost
☐ Lack of training/skills
☐ Resistance from colleagues
☐ Time constraints
☐ Lack of institutional support
☐ Technology is too complex
☐ Incompatibility with current workflows
☐ No perceived advantage over traditional techniques
☐ Other: _____

16. To what extent do you agree with the following statement?

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I feel confident using digital tools in prosthodontics.	☐	☐	☐	☐	☐

16. Would you be interested in receiving structured training in digital prosthodontic tools?

☐ Yes ☐ No ☐ Not sure

17. Preferred method of training:

☐ In-person workshops ☐ Online courses
☐ University-based CPD programs ☐ Industry training sessions
☐ None

18. Do you believe digital prosthodontics should be fully integrated into dental curricula?

☐ Yes ☐ No ☐ Not sure

https://doi.org/10.11138/oi.v18i1.219