



Original Article

The application of teledentistry for Saudi patients' care: A national survey study



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Abstract *Background/purpose:* Teledentistry has emerged as a new communication tool in various dental disciplines around the world. The aim of this study was to investigate the applicability and reliability of teledentistry in the field of diagnostic dentistry and explore the perception of Saudi dentists of its benefits and concerns.

Materials and methods: An electronic survey with 40 questions was developed, validated and distributed electronically by email and social media channels to dentists from different specialty in Saudi Arabia. Collected data were analyzed for statistical significance.

Results: A total of 148 dentists completed the survey. The current data demonstrated that 50% of study participants have had applied teledentistry in their clinical practice. Out of all, 90% have computers in their dental offices and 72% have been using electronic medical records in which radiographs and clinical images are uploaded. Most participants had smart phones (91%), in which they were used more commonly (74.3%) than conventional cameras (54.1%) to capture and share patients' clinical images over communication applications (74.3%) and less likely through emails (62.2%). Overall, 83% were confident that teledentistry can improve daily dental practice, specifically in the fields of oral radiology followed by endodontics and oral medicine.

Conclusion: Teledentistry is an emerging tool with potential to improve the delivery of diagnostic dental care for communities with limited or no access to dental specialists. As of today, teledentistry has not been truly implemented by the Saudi dental community. Development of national

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programs to educate the public and promote teledentistry among dental practitioners are warranted.

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Introduction

Telemedicine is defined as the use of advanced information technologies and electronic tools of communication for the exchange of medical information. It facilitates consultation with patients, specialists and/or health care providers at a distance in order to provide optimized medical services in the patient's physical absence.^{1,2} The original concept was developed to equip health care providers with a communication method to obtain detailed history and clinical observations, including images for diagnosis and guidance.³ This concept has evolved over the past few years and became an essential component of health care delivery around the globe. A recent report by Fortune Business Insights predicted the telemedicine market to grow from USD 34 billion in 2018 to 185 billion in 2026 with domination in the North American segment.⁴

Teledentistry, similar to telemedicine, has emerged as a new tool with promising benefits for various dental disciplines including endodontics, orthodontics, oral surgery and pediatric dentistry.^{1,5} It holds the potential to improve access to, and delivery of oral healthcare in rural and underserved areas.^{2,6} In addition, teledentistry has the potential to save resources and reduce the overall cost of healthcare.^{1,7} An Australian study reported potential savings up to 40 million dollars per year if teledentistry was implemented for screening of low caries risk children.⁸ In diagnostic dentistry, proper diagnosis of oral lesions, including oral cancer, can be challenging, especially in underserved communities with limited access to specialized dental care. Therefore, teledentistry may fill this gap and improve standard of care.

Considering the lack of available literature, the primary purpose of this study was to investigate the applicability and reliability of teledentistry in the field of diagnostic dentistry and explore the perception of Saudi dentists of its benefit and perceived concerns. We believe that this study will be a great addition to the teledentistry literature specifically in Saudi Arabia.

Materials and methods

A human research ethical approval was obtained through King Abdulaziz University – Faculty of Dentistry (KAU-FD). This was a cross sectional study to include a convenient sample of dentists from all dental specialties currently working in Saudi Arabia.

The survey consisted of a total of 40 questions to inquire about dentists' demographic information, clinical experience, specialty, and average number of patients seen. The participants were asked about their familiarity and

expertise in using electronic communication devices to evaluate their perception of incorporating teledentistry in their dental practices. The survey also included questions about dentists' attitude, experience, application, and advantages of teledentistry in their respective specialties. Prior to launching the study, the survey was validated through a selected sample of dental specialists at KAU-FD and was modified based on participants' feedback. Afterward, the survey was distributed electronically via email and different social media channels to study group. Participants' responses were summarized in Table 1. Chi-square test was used to compare responses between dentists who reported using teledentistry and participants who did not use it. Data analysis was completed using SPSS version 18.0 (SPSS Inc., Chicago, IL, USA).

Results

A total of 300 dentists were contacted, in which 148 participated and completed the survey (49%). All demographic data of study participants are summarized in Table 1. Half of the participants (50.0%) reported using teledentistry in the past.

Out of 148 dentists, there were 89 (60.1%) males; 105 (70.9%) were within the age range of 18–35 years and 43 (29.1%) were 36 years or older. The work experience in the dental field differed between participants as 96 participants (64.9%) had 0–5 years of experience since they graduated dental school while 52 (35.1%) had more than 5 years of dental experience. Dental specialists and consultants were more likely to have used teledentistry compared to general dentists ($p = 0.018$). Accounting for type of specialty, specialists and consultants were also more likely to implement teledentistry versus general dentists ($p = 0.002$). In addition, dentists who reported taking clinical images and radiographs more frequently were more likely to have used teledentistry in the past ($p < 0.001$ and $p = 0.004$ respectively) (Table 1).

When asked about having a computer or a laptop in the dental office, 90.5% of participants reported having at least one device which was most likely shared with other dental staff. Overall, 72.4% of participating dentists have been using electronic medical records, in which radiographs (82.1%) and to a lesser extent images (58.2%) get uploaded or linked to the electronic health record system. All participants reported having an active email address, accessed regularly from a desktop, laptop, or smart phone and this finding in particular was a significant predictor for the likelihood of having used/applied teledentistry ($p = 0.047$, $p = 0.002$, $p < 0.11$ respectively). Most of the participants had a smart phone (91.2%) and those who did not were less likely to have used teledentistry before ($p = 0.009$).

Table 1 Demographic data of survey participants.

Item	Category	n (%)	Previous experience with tele-dentistry		p-value
			Yes n = 74 (50.0%)	No n = 74 (50.0%)	
How old are you?	18-35 y	105 (70.9%)	50 (47.6%)	55 (52.4%)	0.365
	>36	43 (29.1%)	24 (55.8%)	19 (44.2%)	
What is your gender?	Male	89 (60.1%)	42 (47.2%)	47 (52.8%)	0.401
	Female	59 (39.9%)	32 (54.2%)	27 (45.8%)	
How many years of experience do you have since you graduated dental school?	0-5 y	96 (64.9%)	48 (50.0%)	48 (50.0%)	1.0
	More than 5 y	52 (35.1%)	26 (50.0%)	26 (50.0%)	
What is your clinical rank?	General Dentist	80 (54.1%)	32 (40.0%)	48 (60.0%)	0.018
	Specialist	37 (25.0%)	25 (67.6%)	12 (32.4%)	
	Consultant	31 (20.9%)	17 (54.8%)	14 (45.2%)	
In which sector do you work?	Government	103 (69.6%)	48 (46.6%)	55 (53.4%)	0.211
	Private	45 (30.4%)	26 (57.8%)	19 (42.2%)	
What is your specialty?	General dentist	71 (48.0%)	27 (38.0%)	44 (62.0%)	0.002
	Oral medicine	13 (8.9%)	5 (6.9%)	8 (10.8%)	
	Oral pathology	3 (2.1%)	1 (1.4%)	2 (2.7%)	
	Oral radiology	3 (2.1%)	2 (2.8%)	1 (1.4%)	
	Oral surgery	14 (9.6%)	10 (13.9%)	4 (5.4%)	
	Prosthodontics	13 (8.9%)	7 (9.7%)	6 (8.1%)	
	Endodontics	4 (2.7%)	0	4 (5.4%)	
	Periodontics	7 (4.8%)	7 (9.7%)	0	
	Pedodontics	3 (2.1%)	1 (1.4%)	2 (2.7%)	
	Orthodontic	7 (4.8%)	6 (8.3%)	1 (1.4%)	
	Dental public Health	5 (3.4%)	4 (5.6%)	1 (1.4%)	
	Advanced general dentistry	2 (1.4%)	1 (1.4%)	1 (1.4%)	
	Restorative dentistry	2 (1.4%)	2 (2.8%)	0	
	In the past 12 months, in an average week, how many hours per week do you practice dentistry?	1–24 h	67 (45.3%)	31 (46.3%)	
>25 h		81 (54.7%)	43 (53.1%)	38 (46.9%)	
In the past year, in an average week, how many patients do you see per week?	1-10 patients	52 (35.1%)	26 (50.0%)	26 (50.0%)	0.587
	11-20 patients	41 (27.7%)	23 (56.1%)	18 (43.9%)	
	21 patients or more	55 (37.2%)	25 (45.5%)	30 (54.5%)	
How many patients per week, do you take photos for?	None	42 (28.4%)	8 (19.0%)	34 (81.0%)	<0.001
	Some patients	77 (52.0%)	43 (55.8%)	34 (44.2%)	
	Most or all patients	29 (19.6%)	23 (79.3%)	6 (20.7%)	
How many patients per week do you take dental radiographs for?	None	29 (19.6%)	19 (65.5%)	10 (34.5%)	0.004
	Some patients	55 (37.2%)	18 (32.7%)	37 (67.3%)	
	Most or all patients	64 (43.2%)	37 (57.8%)	27 (42.2%)	

Interestingly, less than a third of the participants were familiar with the term teledentistry (28.4%). However, after reading the definition, 30.2% of those who were not familiar with term reported having applied teledentistry at some point in the past (Table 2).

A question on participants' impression for which dental specialty to best implement and benefit from teledentistry indicated oral radiology to come first (53.4%), followed by endodontics (47.3%), and oral medicine (45.3%). At the same time, periodontics came last (25.7%) to benefit from teledentistry. The majority of participants (83.8%) were confident that teledentistry has the potential to improve daily dental practice, saves time, and reduces overall cost but not as effective in enhancing communication with

peers, improves case diagnosis, and helps with new patients' referrals (Table 3).

With regards to participants' previous experience with teledentistry, 64.9% of all subjects have implement it for diagnosis and 73.0% to obtain a second opinion from those who have used it before. Further analysis demonstrated radiographs as most commonly shared among clinicians (68.9%), followed by images of oral mucosal lesions (52.7%), and root canal related cases (43.2%). Patient's images were more commonly captured using smart phone (74.3%) than regular cameras (54.1%) and transferred over (62.2%). Teledentistry users who reported confirming initial diagnosis via teledentistry portals (59.5%), less than half of them confirmed the diagnosis with a clinic visit

Table 2 Participants attitude toward application of teledentistry.

Item	Category	n (%)	Used tele-dentistry		p-value
			Yes n = 74 (50.0%)	No n = 74 (50.0%)	
Do you have a computer/laptop in your dental office/ practice?	Yes	134 (90.5%)	66 (49.3%)	68 (50.7%)	0.574
	No	14 (9.5%)	8 (57.1%)	6 (42.9%)	
Are you the main computer user?	Yes	55 (41.0%)	31 (56.4%)	24 (43.6%)	0.170
	No	79 (59.0%)	35 (44.3%)	44 (55.7%)	
Do you use as an electronic medical record?	Yes	97 (72.4%)	50 (51.5%)	47 (48.5%)	0.390
	No	37 (27.6%)	16 (43.2%)	21 (56.8%)	
Do patient's radiographs get uploaded/linked to the electronic record you use?	Yes	110 (82.1%)	57 (51.8%)	53 (48.2%)	0.204
	No	24 (17.9%)	9 (37.5%)	15 (62.5%)	
Do patient's clinical image get uploaded/linked to the electronic record?	Yes	78 (58.2%)	40 (51.3%)	38 (48.7%)	0.579
	No	56 (41.8%)	26 (46.4%)	30 (53.6%)	
Do you have an email?	Yes, personal	44 (29.7%)	22 (50.0%)	22 (50.0%)	0.014
	Yes, professional	17 (11.5%)	3 (17.6%)	14 (82.4%)	
	Yes, personal and professional	87 (58.8%)	49 (56.3%)	38 (43.7%)	
How do you access the email? check all that applies	Desktop	66 (44.6%)	39 (59.1%)	27 (40.9%)	0.047
	Laptop	90 (60.8%)	54 (60.0%)	36 (40.0%)	
	Tablet	22 (14.9%)	13 (59.1%)	9 (40.9%)	
	Smart phone	116 (78.4%)	67 (57.8%)	49 (42.2%)	
How often do you use your email?	Daily	114 (77.0%)	65 (57.0%)	49 (43.0%)	0.002
	Weekly	34 (23.0%)	9 (26.5%)	25 (73.5%)	
In a typical day, about how many emails do you send?	0–10	132 (89.5%)	70 (53.0%)	62 (47.0%)	0.034
	>10	16 (10.8%)	4 (25.0%)	12 (75.0%)	
Do you send clinical images of patients by email?	Yes	41 (27.7%)	21 (51.2%)	20 (48.8%)	0.854
	No	107 (72.3%)	53 (49.5%)	54 (50.5%)	
Do you have a smart phone	Yes	135 (91.2%)	72 (53.3%)	63 (46.7%)	0.009
	No	13 (8.8%)	2 (15.4%)	11 (84.6%)	
Do you use your smart phone in patient related matters?	Yes	107 (79.3%)	64 (59.8%)	43 (40.2%)	0.003
	No	28 (20.7%)	8 (28.6%)	20 (71.4%)	
Do you take patients clinical images with your smart phone?	Yes	84 (62.2%)	49 (58.3%)	35 (41.7%)	0.135
	No	51 (37.8%)	23 (45.1%)	28 (54.9%)	
Do you send clinical images through smart phone applications to colleagues for consultations?	Yes	97 (71.9%)	60 (61.9%)	37 (38.1%)	0.002
	No	38 (28.1%)	12 (31.6%)	26 (68.4%)	
Do you know what teledentistry means?	Yes	42 (28.4%)	42 (100%)	0 (0%)	<0.001
	No	106 (71.6%)	32 (30.2%)	74 (69.8%)	

(45.5%) and 45.5% patients of all had an accurate diagnosis. More than two thirds of teledentistry users (68.9%) were confident of teledentistry to be sufficient to generate an accurate diagnosis and start treatment (Table 4). The current data reported 44 doctors to confirm the oral lesion diagnosis with either a clinical visit (30/44), treatment or biopsy and false diagnosis in 4 out 44 patients (9%)

Discussion

The concept of teledentistry was initially proposed by the American Army as part of the Total Dental Access Project in 1994.⁹ The main goal was to improve the efficiency of

dental services delivered to soldiers. Nowadays, teledentistry is widely accepted in the fields of dental education, public awareness, and research activities within several dental disciplines. Using teledentistry, dental consultations may take several formats including "Real-time Consultation" and "Store-and-forward".¹ Real-time Consultation necessitate a dentist–patient interaction, which takes place over a videoconference. In this portal, dental professionals and their patients are able to communicate effectively while being physically present at different locations.¹ On the other hand, the exchange of static images and clinical information between dental practitioners, known as Store-and-forward, is more likely aimed at interpretation and treatment planning of dental patients.¹ Typically, store-and-forward format uses e-mails

Table 3 The dentists' perception on the best specialties served by teledentistry and its advantages.

Item	Responses	n (%) out of 148
In your opinion, which specialty is to best benefit teledentistry? check all that applies	Oral radiology	78 (53.4%)
	Endodontics	70 (47.3%)
	Oral medicine	67 (45.3%)
	Oral pathology	57 (38.5%)
	Oral surgery	48 (32.4%)
	Prosthodontics	47 (31.8%)
	Orthodontics	47 (31.8%)
If you needed a consultation in an oral lesion, do you think the oral medicine specialist needs to see the patient?	Yes	131 (88.5%)
	No	17 (11.5%)
Will teledentistry improve dental practice?	Yes	124 (83.8%)
	No	24 (16.2%)
Do you think it saves time?	Yes	116 (87.4%)
	No	32 (21.6%)
Do you think it is cost-effective?	Yes	90 (60.8%)
	No	58 (39.2%)
What are the advantages of teledentistry? choose all that applies	Enhancing communication with peers	81 (54.7%)
	Help with guidance and referral of new patients	75 (50.7%)
	Improve patient management	67 (45.3%)
	Increase patient satisfaction	44 (29.7%)
	Increase practice efficiency and production	61 (41.2%)
	Improve case diagnosis	78 (52.7%)
	Decrease appointment time	53 (35.8%)
	Improve record quality	44 (29.7%)

and smart phones which have been on the rise among dental practitioners.⁹

In general, dentists around the globe have supported the application of teledentistry and its potential advantages of time and cost effectiveness, enhancing communication with treating doctors in addition to increasing the quality of diagnosis and treatment planning as well as patient satisfaction.¹⁰ In the current study, 70.9% of participants aged between 18 and 35 years and 28.4% were familiar with the term teledentistry; however, around half of dentists were aware of its components and have applied it previously in their daily practice. These results are relatively higher compared to averages in an Indian study which

Table 4 Teledentistry experience among dentists.

Item	Response	n (%) out of 74
Have you used teledentistry for dental diagnosis?	Yes	48 (64.9%)
	No	26 (35.1%)
Have you used teledentistry for second opinion?	Yes	54 (73.0%)
	No	20 (27.0%)
What are the cases you used teledentistry for? check all that applies	Radiographs	51 (68.9%)
	Oral medicine conditions	39 (52.7%)
	Endodontics-related	32 (43.2%)
	Prosthodontics-related	23 (31.1%)
	Orthodontics-related	20 (27.0%)
What did you use to get the clinical images with? check all that applies	Periodontics-related	18 (24.3%)
	Conventional camera	40 (54.1%)
	Smart phone	55 (74.3%)
What did you use to send it? check all that applies	WhatsApp	55 (74.3%)
	Email	46 (62.2%)
Did you confirm the diagnosis that you got through the tele-dentistry process	Yes	44 (59.5%)
	No	30 (40.5%)
How did you confirm the diagnosis? Check all that applies. (n = 44)	The patient went to see the doctor directly	20 (45.5%)
	The suggested treatment was effective	14 (31.8%)
	The biopsy proved the diagnosis was correct	10 (22.7%)
	Relatively speaking, how accurate was the diagnosis? (n = 44)	Very accurate
Do you think teledentistry is enough for the diagnosis to be able to start treatment?	Not accurate but close enough	15 (34.1%)
	Not correct	4 (9.1%)
	Not sure	5 (11.4%)
	Yes	51 (68.9%)
	No	23 (31.1%)

demonstrated only 7.23% of responding dentists to know the concept of teledentistry and 98% having never practiced it.¹¹ One explanation could be related to the younger population of included participants who are more familiar with dental technology advancements.

The importance of teledentistry among various dental disciplines may vary. Our data have demonstrated specialties such as prosthodontics, and endodontics to more likely implement teledentistry compared to oral medicine,

oral pathology, and oral radiology. One explanation could be the difference in the total number of registered dentists for each specialty which would reflect on the participants' responses.¹² Development and implementation of educational campaigns to increase awareness and encouragement of teledentistry among dentists including young general dentists with limited clinical experience may help in improving standard of care delivered to patients in need.

Electronic medical records have been on a mission to replace conventional charts in almost all medical and dental centers in the last decade around the globe.¹³ In the current study, 90% of participants reported having a computer/laptop in their workplace and 82% have used electronic medical records before. Although 18% of participants have been relying on paper-based medical records, this carries the potential of consuming space and increasing risk of loss of patients' data and/or breach of confidentiality. It may also hinder the use of teledentistry especially in remote counties in which teledentistry has significant potential to improve the quality of care delivered local communities.¹⁴

Based on the current data, smart phones were the preferred method for sharing patients' images and radiographs among dentists. The main reason for this practice is accessibility and the user-friendly nature of smart phones nowadays. However, this practice may risk patients' privacy compared to encrypted emails which should be emphasized all times during the exchange of information.¹⁵ On the other hand, several communication applications (e.g. WhatsApp© and Telegram©) have recently become encrypted to dissipate the public privacy concerns.^{15,16} Yet, all health care providers are expected to consider the importance of data privacy when using smart phones for sharing patients' related materials.

Overall, dentists in Saudi Arabia were more supportive for the application of teledentistry in oral radiology, endodontics and oral medicine specialties compared to other disciplines. In addition, teledentistry has been successfully integrated in various dental disciplines around the world without reported advantage of one specialty over another. In endodontics, no statistical difference was reported between interpretations of periapical bone lesions via video-conference or view-box conventional methods.¹⁷ Another study assessing images of root canal orifices in endodontically accessed teeth obtained with an intraoral camera has reported 87% of root canal orifices to be correctly marked by image observers.¹⁸ Other dental specialties have benefited from teledentistry such as orthodontics which was explored in several studies. A cross-sectional study of orthodontic consultants' attitude in United Kingdom toward teleconsultation was conducted.¹⁹ In this study, more than 50% of participants were confident in offering diagnostic advice to dental practitioners and their patients from a geographic distance. A study by Moylan et al. reported high accuracy in assessing linear tooth movement, intercanine and intermolar width measurements calculated using teledentistry and a software for orthodontic treatment monitoring purposes compared to real time.²⁰ Other studies by Mandall demonstrated that teledentistry has been used as a frequent screening tool for patients' referrals to orthodontist and reducing inappropriate referral rates.^{21,22} In the field of oral surgery, application of teledental systems

for clinical diagnosis of impacted or semi-impacted third molars has been investigated.²³ Using this system, oral surgeons have been able to view radiographs along with intraoral and extraoral images over a web server and made remote diagnoses accordingly which were similar to real-time assessment obtained by clinical diagnoses.

A multiple series of studies addressed the role of teledentistry in preventive and pediatric dentistry and its feasibility in the diagnosis and detection of early childhood caries. The results reported no significant difference between teledentistry and visual/tactile screening for dental caries in young children.²⁴ As a result, intraoral cameras have been proposed as a feasible and potentially cost-effective alternative to visual oral examination for caries screening, especially early lesions in preschool children.²⁵ Additionally, teledentistry via cellular smart phones was proven reliable in diagnosis and treatment planning for younger patients.²⁶

Similar to other dental disciplines, multiple studies were conducted to investigate the role of teledentistry in oral medicine. Access to oral medicine specialists has been challenging historically due to the limited number of practicing specialists resulting in longer waiting time. Therefore, screening for oral lesions using static images may reduce patients' suffering and decreases financial costs.⁹ As such, the feasibility of distant diagnosis of oral lesions using emails as a primary source of image transmission has been investigated before.²⁷ In this study, images of 25 oral lesions obtained from patients in a primary care public health clinic in Brazil were forwarded to two oral medicine consultants.²⁷ At the end of the study, both consultants agreed on 60% of included cases diagnoses. However, there was disagreement in 28% of cases and the diagnosis was inaccurate for 12% of cases.²⁷ Another study in India reported high reliability in diagnosis of "normal" from "abnormal" oral findings through sharing of intraoral images over smart phone messaging application. However, the reported reliability was lower for actual diagnosis.²⁸ In Belfast, researchers were able to support teledentistry use as an alternative approach to manage referrals in oral medicine and help treatment prioritization to decrease the waiting time for appointments.²⁹ Comparing these data with the current study, 68.9% of Saudi dentists who had previously applied teledentistry reported acceptable diagnosis reliability confirmed by clinical visits (45.5%), response to treatment (31.8%), and/or biopsy report (22.7%) which may justify starting needed treatment. In conclusion, Teledentistry is an important communication method with a significant potential to improve patients' dental care. In addition to time and cost effectiveness, it has the potential to be implemented in all branches of dentistry mainly in oral radiology, endodontics as well as oral medicine. Therefore, promotion of teledentistry application in patient care is advised for both private and government sector particularly in remote areas. In addition, national programs are needed to educate the public and facilitate implementation.

One limitation of this study is the overall low response rate. Even with reaching out to 300 practicing dentists in Saudi Arabia and following up with frequent reminders, only 49% of participants have completed the survey. One explanation could be the length of the survey (average

5–12 min to complete) as our records have shown several attempts to access the survey without responding to all questions. Although this study sample may not represent the whole Saudi dental community, it provides a valuable data to better understand the perception toward teledentistry in this group of dentists.

Declaration of Competing Interest

The authors have no conflicts of interest relevant to this article.

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