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Original Article

Accuracy and perceptions of teledentistry in KSA during the COVID-19 pandemic: A single-centre randomised controlled trial

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الملخص

أهداف البحث: يقدم طب الأسنان الاتصالي رعاية صحية للأسنان عند تعذر زيارة عيادة الأسنان مثل أوقات جائحة كوفيد-١٩. هدف هذه الدراسة هو تقييم دقة طب الأسنان الاتصالي في تشخيص حالة المرضى مقارنة بتشخيص زيارة عيادة الأسنان التقليدية وتقييم الانطباعات والمعرفة والسلوك والتحديات لدى مرضى الأسنان عن طب الأسنان الاتصالي، خلال جائحة كوفيد-١٩ في المملكة العربية السعودية.

طرق البحث: تم استخدام دراسة عشوائية محكمة متوازية ومعمية لجهة واحدة. تم توزيع 70 مشارك بشكل عشوائي إلى مجموعتين: مجموعة التجربة ومجموعة ضابطة. خضعت مجموعة التجربة إلى التشخيص عن طريق طب الأسنان الاتصالي، في حين كانت المجموعة الضابطة في فترة الانتظار. تم مقارنة نتائج تشخيص مجموعة التجربة بنتائج تشخيصهم السريرية الأولية في ملفات مستشفى الأسنان. بعد انتهاء التجربة أجاب جميع المشاركين من المجموعتين على أسئلة استبانة الدراسة.

النتائج: لا توجد فروق ذات دلالة إحصائية بين المجموعتين في المعرفة والسلوك تجاه طب الأسنان الاتصالي، ولكن حصلت مجموعة التجربة على تجربة إيجابية أعلى مقارنة بالمجموعة الضابطة. بلغت دقة تشخيص مجموعة التجربة باستخدام طب الأسنان الاتصال مقارنة بنتائج التشخيص السريري الأولي على النحو التالي: 74.3% بالنسبة للشكوى الأساسية، و74.3% بالنسبة لعدد الأسنان المفقودة، و71.4% للأسنان المعالجة بالحشوات، و65.7% لحالة نظافة الفم. بلغت دقة التشخيص 51.4% للمشاكل الصحية، و 40% لتشخيص تسوس الأسنان. عند استخدام طب الأسنان الاتصالي تم تشخيص عدد أكبر في الأسنان المصابة بالتسوس، وعدد أكبر في مؤشر الأسنان المتحللة

والمفقودة والممتلئة بفارق ذو دلالة إحصائية، عند مقارنتها بنتائج التشخيص السريري الأولي.

الاستنتاجات: يحظى طب الأسنان الاتصالي بقبول واسع بين مرضى الأسنان ويمكن أن يستعمل بشكل فعال لفحص الأسنان بشكل مبدئي، خصوصا خلال فترات الحجر الصحي خلال الأوبئة، لكن يجب أن يتبعه فحص سريري في العيادة للحصول على تشخيص اكثر دقة.

الكلمات المفتاحية: طب الأسنان الاتصالي؛ الطب الاتصالي؛ تشخيص؛ كوفيد-١٩؛ دراسة عشوائية محكمة.

Abstract

Objective: Teledentistry conveniently delivers dental care when in-person visits are restricted, such as during the COVID-19 pandemic. This study aimed to assess Saudi Arabian patients' accuracy, perceptions, knowledge, attitudes, and challenges regarding teledentistry used for diagnosis during the COVID-19 pandemic, as well as its accuracy, versus traditional dental visits.

Methods: A single-blind, parallel-group randomised controlled trial design was used. The 70 participants were randomised equally into study and control groups. While the control group waited, the study group received teledentistry diagnoses which were compared with baseline clinical examinations retrieved from the UQU dental hospital, Makkah, KSA. After the intervention was completed, all participants answered a questionnaire.

Results: There were no significant differences between the groups in knowledge or attitudes regarding teledentistry. However, study group participants had more favourable experiences with teledentistry. They reported

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good accuracy with diagnosis and recording of their chief complaints (74.3%), number of missing teeth (74.3%), number of filled teeth (71.4%), and oral hygiene status (65.7%). Additionally, moderate accuracy was reported on recording of health complaints (51.4%) and number of decayed teeth (40.?%). The number of decayed teeth and the decayed, missing, and filled teeth (DMF) index scores reported using teledentistry were significantly ($p < 0.05$) higher than reported in the baseline examinations.

Conclusion: Teledentistry is widely accepted by patients and can be efficient for preliminary examinations, particularly during pandemic lockdowns or in more frequently occurring situations such as severe weather conditions, but subsequent clinical examination is necessary for maximally accurate diagnoses.

Keywords: COVID-19; Diagnosis; Randomised clinical trial; Teledentistry; Telehealth

Introduction

In December 2019, the emergence of COVID-19, caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was reported in Wuhan, China, and it quickly spread worldwide.[1] As the outbreak reached pandemic status, many researchers called COVID-19 the most severe public health threat of this decade.[2-4] Consequently, the rapid spread of COVID-19 was countered with strict quarantine protocols, including staying home and, when necessary to venture out, practicing social distancing and observing heavy restrictions being imposed on daily activities in many countries worldwide.[2-4] Dental care offices are considered a high-risk environment for cross-infection among dental practitioners and patients because the SARS-CoV-2 virus is transmitted by salivary aerosol, and it was found that the virus remains in the air for at least 3 hours and survives up to 72 hours on plastic and stainless steel surfaces.[3,5,6] Hence, additional management procedures have to be taken to provide effective infection control.[3,5,6] Nevertheless, studies have also suggested that dental care has to be maintained during the COVID-19 pandemic, especially for those in great need of dental follow-up care, such as older patients and orthodontic patients.[7,8] Therefore, one of the suggested modalities for treating this group of patients is telehealth, or, for dental care, teledentistry.[9]

Teledentistry is defined as 'the remote provision of dental care, advice, or treatment through the medium of information technology, rather than through direct personal contact with any patient(s) involved'.[10] In fact, teledentistry might be a convenient way to reduce the number of dental clinic visits while still maintaining as high levels of dental health care as possible.[11] Other researchers have suggested that teledentistry can help reduce the financial burden of dental clinic visits due to the increased cost of dental treatment incurred to maintain the strictly required additional personal protective equipment (PPE)[11,12] during the COVID-19 outbreak.[7] Most of the available studies in the literature found that teledentistry is an effective method for patient screening, diagnosis, evaluating emergencies, monitoring treatments, long-term follow-up, consulting, and proposing dental treatment plans.[9] Caries detection, preliminary diagnosis of oral pathologies, and general oral health assessments could also be conducted with teledentistry.[13,14]

However, few studies have assessed these possibilities using an interventional study design, but three randomised controlled trials (RCTs) were conducted to assess teledentistry.[15-17] The first found teledentistry to be effective for screening orthodontic and referral cases.[17] The second found teledentistry useful for diagnosing an impacted third molar; the researchers suggested it was equivalent to an in-person diagnosis.[16] The third study found teledentistry to have acceptable levels of reliability in detecting dental caries among preschool children.[15] However, none of these studies involved mixed or permanent dentition, and the researchers used intraoral photographs that were taken by trained assistants.[18] This means that teledentistry was not examined in the kind of real-world conditions that can occur, such as when professional photographs are impractical because of a lockdown, similar to the situation faced during the COVID-19 pandemic.

Although some cross-sectional studies have indicated positive attitudes about teledentistry among dental professionals in many countries,[19-21] including KSA,[22] thus far, no similar studies have investigated the validity or accuracy of teledentistry in KSA, specifically, those that used an experimental study design. Therefore, this study aimed to use an RCT study design to assess dental patients' accuracy, knowledge, attitudes, perceptions, and challenges regarding teledentistry used for diagnosis during the COVID-19 pandemic, as well as its accuracy, as opposed to regular dental visits, in KSA.

Materials and Methods

Study design and participants

In addition to using a single-blind, parallel-group RCT design (participants were blinded), the statistician used for this study was blinded to whether a patient was in the study group (SG) or the control group (CG). The CONSORT statement guidelines were followed in the reporting of this trial. Adult patients were recruited from Umm Al-Qura University (UQU) dental school in Makkah, KSA. The inclusion criteria were 1) patients who are Arabic-speaking, 2) adults older than 18 years living in KSA, 3) own a smartphone with the WhatsApp social media platform, and 4) have a valid contact number for communicating during a teledental consultation. The exclusion criteria were patients with hearing problems or patients who did not provide informed consent.

The sample size was calculated using an RCT with two independent samples, continuous outcomes, and a 2-tailed hypothesis formula.[23]

$$n(per\ group) = 2\left(\frac{Z_{1-\alpha/2} + Z_{\beta-1}}{ES}\right)^2$$

$$ES = \left(\frac{minimal\ clinical\ difference}{standard\ devation}\right)$$

The following values were used: $\alpha = 0.05$, β (study power of 90%) = 0.1, constant $Z(1-\alpha/2) = 1.96$, constant $Z(\beta-1) = 1.282$, standard deviation (SD) of teledentistry knowledge from a previous study = 2.56,[22] and a minimal clinical difference of 2. The number of participants per group was 34, and the total required sample size was 68 participants. To take into account an estimated 50% non-response rate, we multiplied the sample size by 1.5 and invited a total of 102 participants for this study, which would result in 51 participants per group.

Setting

Patients were recruited from the data file centre at the UQU dental hospital. The recruitment started on 17/02/2021 and ended on 08/04/2021. We selected patients who had visited the UQU dental hospital to open a dental file (screening patients) and who had clinical examination records. Only patients who opened a file after September 2020 were invited to participate in order to ensure that all the dental records were as recent as possible. The patients' names and contact numbers were retrieved from the electronic records system, and they were contacted by phone to assess their willingness to participate in the study. After the patient verbally provided informed consent, he or she was randomised into either the SG or the CG.

Baseline records of dental examinations for patients in the SG were taken from their files and included their 1) chief complaint, 2) past medical history, 3) dental status, including the decayed, missing, and filled teeth (DMFT) score (based on clinical and radiographic examinations taken by a dental intern during their previous visit to open their file), and 4) oral hygiene status (good, fair, or poor). It should be noted that caries was diagnosed by a dental intern according to the World Health Organization (WHO) criteria. Their criteria for decayed teeth are pits and fissures, smooth surfaces that have an unmistakable cavity, or undermined enamel; a detectable soft floor or wall and pre-cavitation lesions have been excluded.[24] The criterion for a filled tooth is any tooth with temporary or permanent restoration without any sign of decay. Missing teeth include teeth that are missing for any reason, including caries, trauma, and other factors. These data were sealed away from the data collection team and were revealed only after the intervention was conducted so that the data would not influence the data collection team or cause bias.

The SG participants received teledentistry sessions. This was followed by the SG and CG receiving the assessment questionnaire, which evaluated their knowledge, attitudes, and challenges regarding teledentistry. The SG participants' questionnaire had an additional section to measure their perceptions and experiences of teledentistry. The assessment questionnaire was administered only once, immediately after the intervention. All data related to patient identity obtained during the teledentistry sessions were deleted after the assessment was completed, and all data were handled to ensure anonymity.

The intervention

After enrolment, participants in the SG received a message via WhatsApp providing a demonstration video of how to take a proper intraoral photograph. They were then asked to take five intraoral pictures and send them via WhatsApp. WhatsApp was chosen because the platform uses end-to-end encryption, which means it is highly secure, and it helped preserve patient confidentiality. Next, the research team conducted a one-on-one teledentistry session with the participant on a phone call that lasted approximately 10 minutes. The first three minutes included questions about their past dental history to help the data collector gather the proper information regarding their chief complaint and medical history. The next three minutes were devoted to asking further questions related to the intraoral pictures to help assess the DMFT score for each tooth and their oral hygiene status. Further information was provided to the participants as a review of the findings in the pictures they had sent to clarify anything that could not be visualised. During this discussion, the participants were also asked about their last dental visit, other dental symptoms, and their past dental procedures to help make a proper assessment. Subsequently, the data collector discussed the participant's case, giving the participant an emergency evaluation and initial recommendations in simple language. The remainder of the session was dedicated to the participant's questions and concerns.

Afterwards, the participants received an online self-reported questionnaire to assess their knowledge, attitudes, perceptions, and challenges regarding teledentistry.

Control group. The CG received the online self-reported questionnaire to assess their knowledge, attitudes, perceptions, and challenges regarding teledentistry.

Assessment

The instrument of assessment was an online self-reported questionnaire sent as a link to all participants. The five sections of the questionnaire contained 52 closed-ended questions that were mostly adapted from previous studies[12,20,22,25–27] and modified. The first section of eight questions gathered participants' demographic data. The second section, meant to assess their knowledge, included 10 questions with the options 'yes', 'no', and 'I do not know'. Each question was scored based on whether or not they were answered correctly, and the scores were totalled to obtain the knowledge score. The third section assessed the participants' attitudes as measured by 14 statements answered on a Likert-type scale ranging from one (strongly disagree) to five (strongly agree). The fourth section encompassed 10 questions assessing possible barriers or challenges to the

use of teledentistry, which were answered with yes or no. The last section assessed the participants' experiences of the teledentistry session through 10 questions on a Likert-type scale ranging from one (strongly disagree) to 10 (strongly agree). This section was answered only by the participants in the SG.

Ethical considerations

Confidentiality and patient privacy were maintained during the study with measures that included destruction of all potentially identifying information obtained during the tele-dentistry session, such as mobile phone number and photo-graph, after the completion of the assessment. All participants were sent an informed consent form through WhatsApp before starting the study, and they had to reply with the word 'accept' and their name to provide informed consent. These records were kept as evidence of their consent to participate in the study. The study was registered with the ISRCTN registry (ISRCTN29153109).

Data analysis

The Statistical Package for Social Sciences (SPSS) ver.23 (IBM Corp., Armonk, NY, USA) was used for statistical analyses. Descriptive data were presented in graphs and as percentages, counts, means, and SD. As-sessments of relationships between the variables were conducted using the chi-square test, t-test, ANOVA test, and paired t-test. The statistician received data from both groups without knowing which group the study was, and which was the control to ensure the statistician's blindness.

Results

A total of 70 participants agreed to participate in this study, with 35 assigned to the SG and 35 assigned to the CG as shown in Figure 1. This is a response rate of 68.6%. Participants' mean age was 32.3 ± 11.3 years. There was a significantly higher number of females in the CG ($n = 29$, 82.9%) than in the SG ($n = 19$, 65.3%), and no other demographic variables were statistically significantly different between the groups. The demographic data of the participants are presented in Table 1. Among the participants, 17.1% had previously heard about teledentistry, 24.3% assumed they knew what teledentistry is, and 65.7% could identify that teledentistry is the use of the internet and technology to diagnose dental issues via a remote consultation. The chi-square and Fisher's exact tests found no significant differences on these questions be-tween the SG and the CG.
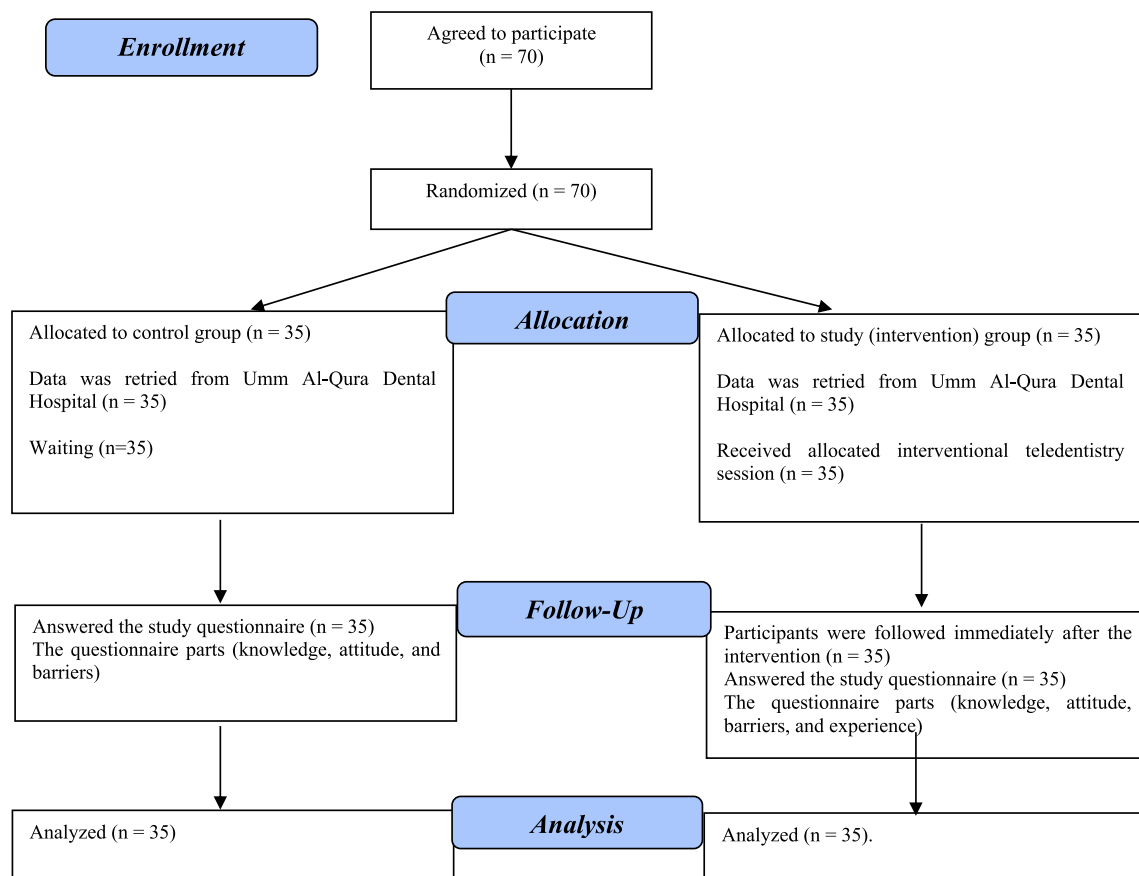

Figure 1: Flowchart showing the steps of the study.

Table 1: Participant demographic data (*n* = 70).

Variables		n	%
Group	Study	35	50.0
	Control	35	50.0
Sex	Male	22	31.4
	Female	48	68.6
Education	Less than high school	6	8.60
	High school	27	38.6
	Bachelor's	31	44.3
	Higher education	6	8.60
Occupation	Student	16	22.9
	Employee	23	32.9
	Without a job or retired	31	44.3
Nationality	Saudi	44	62.9
	Non-Saudi	26	37.1
Do you have a smartphone?	Yes	68	97.1
	No	2	2.90
Do you have internet access?	Yes	69	98.6
	No	1	1.40

Table 2 displays the participants' knowledge about teledentistry. The chi-square test revealed no significant differences between the SG and CG, as shown in Table 2. Participants' attitudes about teledentistry are summarised in Table 3 on a scale of one to five. A t-test showed no significant differences between the SG and CG participants in attitudes regarding teledentistry for all items. The participants' opinions regarding barriers to using teledentistry are provided in Table 4. There were no significant differences between the SG and the CG for any barrier, according to a chi-square test and Fisher's exact test. The participants in the SG recorded their answers to a separate section after their teledentistry session, and the distribution of their responses are shown in Table 5. To assess the accuracy of teledentistry, the teledentistry results were compared with the clinical diagnosis file of each patient. Data were evaluated in terms of the patient's chief complaint, number of similar medical history items, total DMFT score, and oral

Table 2: Participants who answered 'yes' to knowledge items about teledentistry (*n* = 70).

Statement	Total n (%)	Study n (%)	Control n (%)	*p*-value
Teledentistry could reduce in-person dental visits.	52 (74.3)	27 (77.1)	25 (71.4)	0.584
Teledentistry helps monitor the patient's oral health.	45 (64.3)	23 (65.7)	22 (62.9)	0.803
Teledentistry is useful for early and easy consultations with a specialist in oral diseases.	44 (62.9)	20 (57.1)	24 (68.6)	0.322
Teledentistry helps by providing a consultation with an expert on the patient's problem.	43 (61.4)	22 (62.9)	21 (60.0)	0.806
Teledentistry is useful for improving access to oral health care.	35 (50.0)	16 (45.7)	19 (54.3)	0.473
Teledentistry is useful in the diagnosis and management of oral diseases.	28 (40.0)	16 (45.7)	12 (34.3)	0.329
Teledentistry is a good tool for oral hygiene training.	26 (37.1)	13 (37.1)	13 (37.1)	1

Table 3: Participants' attitudes about teledentistry (*n* = 70).

Statement	Total Mean ± SD	Study Mean ± SD	Control Mean ± SD	*P*-value
Would teledentistry help avoid unnecessary travel to hospitals?	4.16 ± 0.75	4.11 ± 0.83	4.20 ± 0.68	0.602
Would teledentistry be helpful with patient education?	4.13 ± 0.70	4.17 ± 0.71	4.09 ± 0.70	0.903
I think the use of teledentistry during COVID-19 is safer than visiting a dentist.	4.03 ± 0.80	4.06 ± 0.76	4.00 ± 0.84	0.330
Teledentistry would improve communication between patients and practitioners.	3.86 ± 0.80	3.80 ± 0.87	3.91 ± 0.74	0.889
Teledentistry would help shorten waiting times for me to receive dental services.	3.81 ± 0.82	3.77 ± 0.84	3.86 ± 0.81	0.651
I think teledentistry can replace in-person visits to a dental practitioner for treatment.	2.79 ± 1.06	2.83 ± 1.12	2.74 ± 1.01	0.480
Would teledentistry be as accurate as a clinical diagnosis?	2.77 ± 1.07	2.91 ± 1.09	2.63 ± 1.03	0.767
I think teledentistry can reduce the costs of dental services.	3.76 ± 0.69	3.71 ± 0.75	3.80 ± 0.63	0.809
Would teledentistry reduce costs for dental practitioners?	3.74 ± 0.83	3.69 ± 0.90	3.80 ± 0.76	0.738
In the future, I think I will use teledentistry for dental purposes for members of my family (children or parents).	3.60 ± 0.91	3.66 ± 0.87	3.54 ± 0.95	0.607
In the future, I think I will use teledentistry for myself.	3.53 ± 0.97	3.51 ± 0.85	3.54 ± 1.09	0.023*
I think teledentistry is very useful in general.	3.47 ± 0.85	3.46 ± 0.89	3.49 ± 0.82	1.000
I think dental examinations through teledentistry are as accurate as face-to-face consultations.	2.91 ± 1.06	3.20 ± 0.93	2.63 ± 1.11	0.806
I think teledentistry can replace visiting a dental practitioner for diagnosis.	3.26 ± 1.05	3.20 ± 0.99	3.31 ± 1.11	0.336

SD − standard deviation.

Table 4: Participants' barriers to teledentistry (n = 70).

Barrier	Total	Study	Control
	n (%)	n (%)	n (%)
Internet connection problems.	34 (48.6)	14 (40.0)	20 (57.1)
Personal accent is a barrier for communication between patient and dental practitioner in teledentistry.	23 (32.9)	11 (31.4)	12 (34.3)
I do not have someone to assist me with taking a photograph for teledentistry.	26 (37.1)	10 (28.6)	16 (45.7)
I am afraid of sending my pictures and information using digital media.	20 (28.6)	9 (25.7)	11 (31.4)
Taking a good photograph on my own for teledentistry is a problem.	19 (27.1)	12 (34.3)	7 (20.0)
Communication in teledentistry is a problem and it is less effective than face-to-face communication with the dentist.	18 (25.7)	9 (25.7)	9 (25.7)
My phone does not have the ability to be used in teledentistry.	13 (18.6)	8 (22.9)	5 (14.3)
I do not have the skills with a smartphone necessary to use for teledentistry.	11 (15.7)	7 (20.0)	4 (11.4)
Teledentistry may threaten my confidentiality.	10 (14.3)	4 (11.4)	6 (17.1)
Teledentistry can violate the patient's privacy.	6 (8.60)	3 (8.60)	3 (8.60)

Table 5: Participants' experiences using teledentistry (n = 35).

Statement	Answered Yes n	%
The dentist understood me properly.	34	97.1
I benefitted from using teledentistry.	33	94.3
I felt secure sending my information and photograph though a mobile application (WhatsApp).	33	94.3
I got a good diagnosis.	33	94.3
It was easy to communicate through teledentistry.	32	91.4
Now I trust teledentistry to provide me with appropriate dental service.	31	88.6
I will use teledentistry again in the future.	31	88.6
I was more comfortable having a teledental consultation than an in-person visit.	28	80.0
I had problems taking the dental photographs.	19	54.3
I had problems with my internet/mobile connection during the teledentistry session.	17	48.6

hygiene status. The results are presented in Table 6. We analysed the data for the health items and DMFT scores using a paired t-test, and the results are shown in Table 7. Decayed teeth and total DMFT scores were

Table 6: Comparison of teledentistry results with clinical diagnosis results.

Item		n	%
Chief complaint	Similar	26	74.3
	Different	9	25.7
Health items	Underestimated	10	28.6
	Accurate	18	51.4
	Overestimated	7	20.0
Decayed	Underestimated	5	14.3
	Accurate	14	40.0
	Overestimated	16	45.7
Missing	Underestimated	3	8.60
	Accurate	26	74.3
	Overestimated	6	17.1
Filled	Underestimated	3	8.60
	Accurate	25	71.4
	Overestimated	7	20.0
DMF score	Underestimated	4	11.4
	Accurate	9	25.7
	Overestimated	22	62.9
Oral hygiene	Underestimated	9	25.7
	Accurate	23	65.7
	Overestimated	3	8.60

Table 7: Paired t-test results of teledentistry compared with clinical diagnosis results.

Statement	Mean ± SD	p-value
Total health record, by clinical examination	1.77 ± 1.52	0.692
Total health record, by teledentistry	1.69 ± 1.51	
Decay level, by clinical examination	5.26 ± 2.92	0.021[a]
Decay level, by teledentistry	6.57 ± 4.51	
Filled teeth, by clinical examination	3.00 ± 3.55	0.447
Filled teeth, by teledentistry	3.09 ± 3.55	
Missing teeth, by clinical examination	2.43 ± 1.97	0.314
Missing teeth, by teledentistry	2.63 ± 2.37	
DMFT score, from clinical examination	10.7 ± 4.65	0.007[a]
DMFT score, from teledentistry	12.4 ± 5.82	

SD − standard deviation.
[a] $p < 0.05$.

significantly higher (overestimated) with teledentistry. We assessed the oral hygiene status assigned by the clinical evaluation versus by teledentistry using the McNemar−Bowker Test, and the results indicated no significant differences between the two measures.

Discussion

This study aimed to investigate the accuracy of teledentistry diagnoses using a DMFT assessment tool and then

determine the patients' experiences during the teledentistry sessions. A small percentage of the participants had previous knowledge of teledentistry. Overall, the participants obtained knowledge scores between 37.1% and 74.3% for the knowledge items on the questionnaire. Participants had highly positive attitudes about teledentistry, especially for avoiding traveling, better patient education, and being safer to use during the COVID-19 pandemic. The most significant reported barrier was internet connection (48.6%), and the other barriers ranged from 8.6% to 32.9%. However, there were no significant differences between the SG and the CG with the knowledge, attitude, and barrier items. The experience of teledentistry for the SG was good, with 97.1−80% reporting a positive experience. However, 54.3% had problems with taking dental photographs, and 48.6% had internet connection problems. The comparisons of the baseline clinical examinations with the teledentistry results showed that there was good accuracy with understanding the patient's chief complaint, the number of missing teeth, the number of filled teeth, and the patient's oral hygiene status. There were moderate levels of accuracy for health issues and the number of decayed teeth. In fact, the number of decayed teeth and the DMFT score were significantly higher with teledentistry than were recorded in the baseline clinical examinations.

A total of 17% of the participants confirmed that they had previously heard about teledentistry; this result is similar to that of a prior study conducted with dental students in KSA (17.2%).[22] However, this percentage was slightly lower than those obtained in other studies in KSA among dental professionals (28.4−33%).[28] The lower percentage in our study (compared with percentages in other studies in KSA) might indicate that teledentistry is an uncommon topic in the public and possibly even among a large segment of dental professionals. This is despite telehealth being used heavily in KSA during the COVID-19 pandemic.[29,30]

According to our results, there were no significant differences between the SG and the CG in their understanding, knowledge, attitudes, and barriers to teledentistry, despite the SG receiving a teledentistry session. This result may be for several reasons. First, a single session may have been inadequate to provide a sufficiently thorough explanation of the capabilities of teledentistry to improve the patients' knowledge, attitudes, and understanding of the barriers to teledentistry, considering that the data collectors did not allocate any time to explain teledentistry to the participants in this intervention. Second, the participants were recruited from a university dental hospital, which could have resulted in a group of participants who have a relatively low socioeconomic status and are seeking free treatment, as seen in the demographic data (44.3% are retired or without jobs). Therefore, such terms might be unfamiliar to them. Third, the low sample size may have reduced the ability to detect statistical differences.

One of the reported barriers was the personal accent, despite all the participants and examiners being Arabic speakers. This might be because Arabic accents in KSA vary depending on geographical location and tribe. This might result in different local Arabic terms to explain dental terminologies.

Overall, the SG had good perceptions of teledentistry, and most of them reported feeling that the dentist correctly understood their problem, believing that they received some benefit from teledentistry, getting a good diagnosis, and having easy communication with the dental professional. Similarly, a previous Australian study found that 80−90% of dental practitioners agreed that teledentistry could improve communication with patients and be a helpful way of educating patients as well.[26] This is important because communication is one of the most important elements in the relationships between health practitioners and patients.[31,32] It is interesting to note that the study's teledentistry session was the first teledentistry experience for many of the participants.

Moreover, it is noteworthy that the majority of the participants in the SG felt secure using the WhatsApp platform for communication. This may be due to a similar effect as was reported in a previous study finding that Saudi dentists often communicate with their patients via social media platforms despite the platforms' lack of strict confidentiality guidelines.[33] This can be an important point to highlight as teledentistry becomes fully operational in the Saudi market.

In addition, the use of the widely popular WhatsApp platform as a free medium of communication could open the path to new horizons of its use, such as the availability of free tools to reduce the cost of building new platforms, which can be a major hindrance to embracing such initiatives on a national scale. Nevertheless, telehealth and teledentistry models have been reported to be cost-effective in many studies.[34,35] In fact, we note that our study was conducted using existing available resources (smartphones) that patients and the research team already owned, and it can be replicated with appropriate precautions to protect patient privacy. This makes it an acceptable method of providing dental services during the COVID-19 and other pandemics or in remote areas where it is difficult to access health care.

A majority of participants in our study reported that they would use teledentistry in the future and that teledentistry is preferable to a face-to-face visit. This is promising for efforts to introduce this service in the dental field in KSA, bearing in mind the major changes that KSA intended with the Vision 2030 reform plans.[22] This might be an indicator of a future market for teledentistry; however, more studies are needed to validate this result, considering the small size of our SG sample.

In terms of experience, however, the participants had two major problems: taking dental pictures and internet connections. Taking pictures is essential to provide accurate diagnoses in teledentistry,[36] and the differences in smartphone capabilities might create limitations for the proper use of teledentistry. While there are some applications that could potentially be used to assist participants with taking better and more accurate photographs,[37] such tools could make teledentistry much more expensive owing to the extra tools patients will need to purchase as compared to our model.

Another problem participants had was difficulty with internet connections, despite the major changes meant to improve access to the internet in KSA according to the Vision 2030 plans. Altogether, it seems that patients with low levels of socioeconomic resources could face problems using teledentistry, which highlights a further important aspect for discussion when introducing the service on an extensive national scale.

The results regarding the accuracy of diagnosis showed that 74.3% of the teledentistry sessions resulted in similar recording of the patient's chief complaint and showed 51.4%

accuracy on the health items recorded. The difference might be due to the time that elapsed between when the patient's file was first opened in the dental hospital and the teledentistry session. We argue that teledentistry may be more accurate in terms of health items recorded because communication by phone gives the dental practitioner more room to discuss each item on the medical history with a patient and get better accuracy. It is recommended that future studies compare the understanding of a patient's chief complaint and their medical history obtained in a face-to-face interaction with that obtained through teledentistry to determine if such differences exist and why. Our study data cannot explain the reasons for these results. Additionally, future studies might assess the usability of teledentistry that utilises text intervention only targeting individuals with hearing disabilities, as it might be more convenient for them.

For the assessment of decayed teeth, only 40% of the teledentistry cases reported an accurate number of decayed teeth; 45.7% were overestimated, and only 14.3% were underestimated. In fact, the mean number of decayed teeth found was significantly higher using teledentistry (0.021) than with a clinical examination; this is similar to the finding of a previous study that used pictures taken by trained practitioners with intraoral cameras.[38] There may be three reasons for this. First, the presence of dental stains on the occlusal surface can be hard to distinguish from occlusal caries, particularly when using low-quality photographs, which makes it even more difficult to diagnose caries without the use of scanners like Explorer (PreXion, Tokyo, Japan).[39] Second, six months passed between the clinical examination and the teledentistry session, which is enough time for caries progression.[40] Third, proximal and hidden caries might not be visible without the aid of X-rays and clinical examinations.[41]

There was a high percentage of accuracy for missing and filled teeth (no statistically significant difference between the two methods); this is similar to the findings of an earlier study.[38] However, there were also high levels of overestimation and underestimation, which could be for the second and third reasons mentioned in the previous paragraph. This demonstrates that teledentistry permits a high level of accuracy in determining the number of filled and missing teeth, but less accuracy with decayed teeth. Nevertheless, it should be noted that our analysis of DMFT components was based on the patient's overall symptoms, not on examinations of individual teeth. In other words, the comparison did not consider sound teeth as a correct answer, which might have resulted in an overestimated error percentage. It is recommended that future studies assess each tooth individually to obtain more accurate results. Some of the errors could also have arisen from the use of uncalibrated dental examiners for the baseline clinical examination when first opening the patients' files.

Additionally, the oral hygiene assessment was classified into poor, fair, and good because the baseline clinical examinations in the dental hospital used this system. It is recommended in future studies to use more reliable systems such as clinical attachment level, plaque index score, and bleeding index score to assess periodontal condition.

We recommend that stakeholders increase educational efforts about teledentistry among the general population to make teledentistry more familiar and increase dental patients' readiness and acceptance, as recommended by other studies.[22] Future research should also use a larger sample size to provide results more generalisable over KSA. Additionally, calibrated clinical dental examiners should be used rather than relying on regular dental records, which were a limitation of the current study.

Conclusion

Teledentistry has generally high rates of acceptance among patients, who also have good perceptions of teledentistry despite problems with taking pictures and their internet connections. Their experiences with teledentistry were insufficient on their own to increase their levels of knowledge and improve attitudes about teledentistry. Teledentistry can be used to successfully record a patient's chief complaint and medical history and to assign the number of missing and filled teeth at acceptable levels. However, teledentistry tends to overestimate the number of decayed teeth. Hence, while teledentistry might be an efficient method of conducting preliminary dental examinations when necessary, such as during the current COVID-19 pandemic, it is necessary to conduct a subsequent clinical examination for the most accurate assessment.

Conflict of interest

The authors have no conflict of interest to declare.

Ethical approval

Ethical approval was secured from the institutional review board of UQU in KSA in 10\1\2021 (approval number HAPO-02-K-012-2021-01-521).

Authors contributions

KTA conceived and designed the study, analysed and interpreted data, and wrote the initial and final draft of the article. TKA conducted research, provided research materials, collected and organised data, and wrote the final draft of the article. SAA conducted research, provided research materials, collected and organised data, and wrote the final draft of the article. SNA conducted research, provided research materials, collected and organised data, and wrote the final draft of the article. AAA conducted research, provided research materials, collected and organised data, and wrote the final draft of the article. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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