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Comparison of mobile application-based teledentistry method with face-to-face oral examination assessment

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Highlights

- By utilizing information and communication technology to provide access to primary, secondary, and tertiary care, teledentistry has potential to enhance oral health care globally.
- Mobile teledentistry applications are a practical and dependable method for providing dental services in areas with poor dental services.
- Following the constraints of the face-to-face dental screening approach, the mobile teledentistry approach may propose a cost-saving alternative to solve care access issues and increased dental care costs.

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Abstract

Aim: The study aims to determine whether the mobile application-based teledentistry method is reliable in diagnosing and treating the intraoral findings of children aged 4 to 15 years by comparing intraoral examination and screening findings of the face-to-face and mobile application-based teledentistry. **Methods:** 115 patients were examined. Two pediatric dentists performed a face-to-face intraoral examination of the patients. Clinical examinations were accepted as the gold standard. Two extraoral and five intraoral images were obtained from the patients. The patient's information and the photos taken were transferred to the "TeleDiş' mobile application developed specifically for the research. Six remote pediatric dental specialists, identified as teledentists, conducted their examinations using photos of the patients obtained through the "TeleDiş" mobile app. The WHO oral health evaluation form for children was adapted and used to record the findings of the patients. When the compatibility between the clinical examination dentists and the teledentistry group in terms of categorical variables, Cohen's Kappa Statistics was used to examine the compatibility between two physicians, and Fleiss' Kappa Statistics was used while examining the compatibility between three or more physicians. **Results:** According to the findings of the study, a statistically significant and very good agreement was obtained between the clinician (gold standard) and teleconsultant physicians in terms of dental examination ($p<0.001$). Specificity results were found to be higher than sensitivity in dental examination parameters. Although the sensitivity is above 80% and the specificity is consistently above 90%, the current model has a higher probability of giving false positive results than false negative results. **Conclusions:** Our study demonstrated that the combination of the store-and-forward method at the mobile application level and the use of a smartphone camera provides a valid and reliable remote scanning method for evaluating intraoral results, despite its current limitations.

Keywords: Mobile Application; Pediatric Dentistry; Smart Phone; Teledentistry

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INTRODUCTION

Telehealth, often known as telemedicine, refers to the use of electronic information and telecommunications technology to deliver care when the patient and physician are not in the exact location at the same time. All medical services in telehealth include diagnosis, treatment, monitoring, prevention, continuing education for healthcare practitioners and patients, research, and evaluations.

Extensive technological innovations have taken place in dentistry in recent years. Advancements have been made to analyze and monitor computers, telecommunications technology, digital diagnostic imaging services, gadgets, and software for analysis and monitoring.[1] Nowadays, the science of dentistry has progressed considerably further than it has been able to through utilizing advanced information technology.[2] The quality of dental patient management has improved because of new information technology, which has also made it "possible to partially or fully manage patients thousands of kilometers away from healthcare facilities or specialist dentists. The part of telehealth science related to dentistry, called "Teledentistry," covers networking, digital information sharing, remote consultations, study, and analysis.[3]

Teledentistry is utilized in pediatric dentistry to promote oral health behaviors and access to oral health care.[4-6] Internet, mobile technology, and mobile health applications can reach a large public because they are readily accessible via smartphones and do not require a separate device.[7,8] Pediatric dentistry can use this technology in; children with limited access to specialist dentists in remote settlements, in patient/parent education, monitoring of preventive treatments and follow-up after treatment, evaluation of tooth development, diagnosis of dental diseases, and treatment planning, performing intraoral scans, pre-appointment behavioral guidance to detect early caries and reduce anxiety among pediatric patients.[9]

The study aims to determine whether the mobile application-based teledentistry method is reliable in diagnosing and treating the intraoral findings of children aged 4 to 15 years by comparing intraoral examination and screening findings of the face-to-face and mobile application-based teledentistry.

METHODS

Ethics committee approval

The ethics committee approval required for the study was obtained from the Non-Invasive Clinical Research Ethics Committee of Sivas Cumhuriyet University Faculty of Medicine on 23.06.2021, with the decision numbered 2021-06/24. To use the children's photographs that were taken in the study, a signed and informed consent form was obtained from the parents of the children. Each patient's file was assigned a unique research number to preserve the confidentiality of the patient's identity. Physicians evaluating patient images via the mobile application needed more information about the patient's real identity and were only informed about the study number.

Sample size

The effect size for the number of patients enrolled in the study, and the number of physicians to examine was created by examining the existing literature on the dependability of teledentistry.[10-13] The number of dentists who will conduct face-to-face examinations in the clinic was determined as two, and the literature revealed that the kappa value for the compatibility between the physicians was obtained as 0.86.[14] Considering these values, the sample size was determined as 48 patients to

compare the compatibility between the two physicians for 95% confidence (1-α), 95% test power (1-β), and a kappa value of 0.86. The number of teleconsultant dentists who will participate in the study via the mobile application was determined as six dentists on a voluntary basis. Considering other reference studies[14], the minimum number of patients to be evaluated by the physicians who will participate via the mobile application was determined as 115 patients with 95% confidence (1-α), 95% test power (1-β), and a kappa value of 0.78.

Inclusion and exclusion criteria

The inclusion criteria were that the patient applied to our clinic for the first time for a routine dental examination, was a cooperative patient between the ages of 4-15, and the child and parents were eager to participate in the study. The exclusion criteria were that the patients did not show the necessary cooperation for the examination, the child and parents did not accept participating in the study, and the patient had a cooperation problem in intraoral photography.

Materials

An iPhone Operating System (iOS) mobile application was developed using the "Store-and-forward" method to facilitate the database's storage, recovery, and management. "TeleDiş" was chosen as the name of the mobile application (Figure 1). This mobile application enables Internet-based photos to be store-and-forward from a smartphone or computer. Apple iPhone 11 (Apple Corp. Cupertino, CA) smartphone was selected for image recording. To run the default camera TeleDiş mobile application was developed for iOS. Before starting the study, an online conference was held with teleconsultant physicians to provide training on the use of the TeleDiş mobile application and on the use of the modified version of the WHO oral health assessment form prepared for children (2013 version), which is also used by physicians who perform face-to-face examinations. (Supplemental File).

Figure 1. Mobile TeleDiş app and home and main screens of the mobile TeleDiş app.

Calibration and selection of dentists

Two pediatric dentists designated to record oral findings in children examined the patients clinically and radiographically face-to-face using the WHO oral health assessment form for children, modified based on expert opinion (Supplemental File). This form has been accepted as the "gold standard" in diagnosis and treatment planning. Using the abovementioned assessment form, dentists who conducted the face-to-face examination first reexamined 20 children at 1-week intervals to self-calibrate. Six pediatric dentistry specialists (with at least five years of experience) designated as teleconsulting physicians were calibrated using the same modified WHO form as the physicians performing the initial examination as comparison criteria. Their initial calibration was performed in a dental clinic with adequate lighting to familiarize dentists with the modified WHO form. Each of the six dentists served as a teledentistry group and made their diagnosis based solely on the images sent to them without using radiography.

Face-to-Face intraoral examination

Informed consent forms were obtained from the patients and their families who agreed to participate in the study. The modified oral health assessment form for children created by WHO (2013 version) was utilized during the oral examination of the patients (Supplemental File). The WHO's oral health evaluation form for children (2013 version) was modified based on the advice of experts for the oral examination of the patients. Before the dental examination, the patient's age, the number of years of formal education, the area or village where the patient resided, and medical and dental history were documented. An intraoral examination was conducted using WHO category I examination standards (professional examination with light and radiographs). The scientists conducted clinical exams using conventional dental equipment, a light reflector, an air-water spray, a No. 5 mouth mirror, a standard probe, and gauze when necessary. The American Academy of Pediatric Dentistry's (AAPD) recommendations for radiographs in children were used to get the appropriate radiographic data. According to the modified WHO form, the parameters in the dental examination were confirmed by the face-to-face physicians, who confirmed the diagnosis with clinical examination and radiographs, then recorded their findings in the modified WHO form.

Patients rated two categories in the modified form employed in examining the oral cavity: dental and general examination. Examinations were conducted per the WHO criteria for assessing the intraoral cavity.[15] To evaluate the status of each tooth individually, clinicians evaluated each tooth under the titles dental examination, dental erosion, and dental trauma. In the general evaluation of the oral cavity, gingival bleeding, periodontal status, orthodontic examination, oral mucosal lesions, and therapy options for the patient were utilized.

Seven pictures were taken for the examination of a patient, all of which were taken by the same physician. A physician who did the examination appropriately positioned the patients after the oral cavity examination, allowing for a better view of the teeth and oral tissues. A cell phone (iPhone 11, Apple Corp. Cupertino, CA) camera was used to capture the photos using autofocus and auto settings. Considering that the patient's family will take the images both in and out of the clinic, the cheeks and lips of the patient or the assisting staff were eliminated using their fingers, a mirror, and a probe. The pictures consist of two extraoral photographs (profile and frontal photographs) and five intraoral photographs (Figure 2 and 3).

Intraoral photographs consist of anterior intraoral, upper occlusal, lower occlusal, right lateral, and left lateral photographs. These

photographs were taken following AAPD recommendations for photographic recordings. Images are 220-800 KB in size and have a minimum resolution of 600 dpi. Pictures are saved in the phone in JPEG format.

Figure 2. Extraoral photographs. a: Frontal view; b: Profile view

Store-and-forward

Patients were registered in order of numbers on the new registration tab of the mobile application. The gender, date of birth, region/village, and medical and dental histories of the patients were uploaded to the mobile application examination system through record creation. There are two methods for uploading images to the mobile application. First, photographs can be captured instantly and uploaded to the system via the mobile application's 'Take Photo' option. Secondly, previously taken and stored photographs can be picked and uploaded using the 'Photo Archive.'The photographs taken and stored by the physician who performed the face-to-face examination were selected and uploaded via the 'Choose file- Photo Archive' tab on the patient data screen. After the patient records and data are uploaded, the records are stored so that teleconsultant physicians can access them through the application.

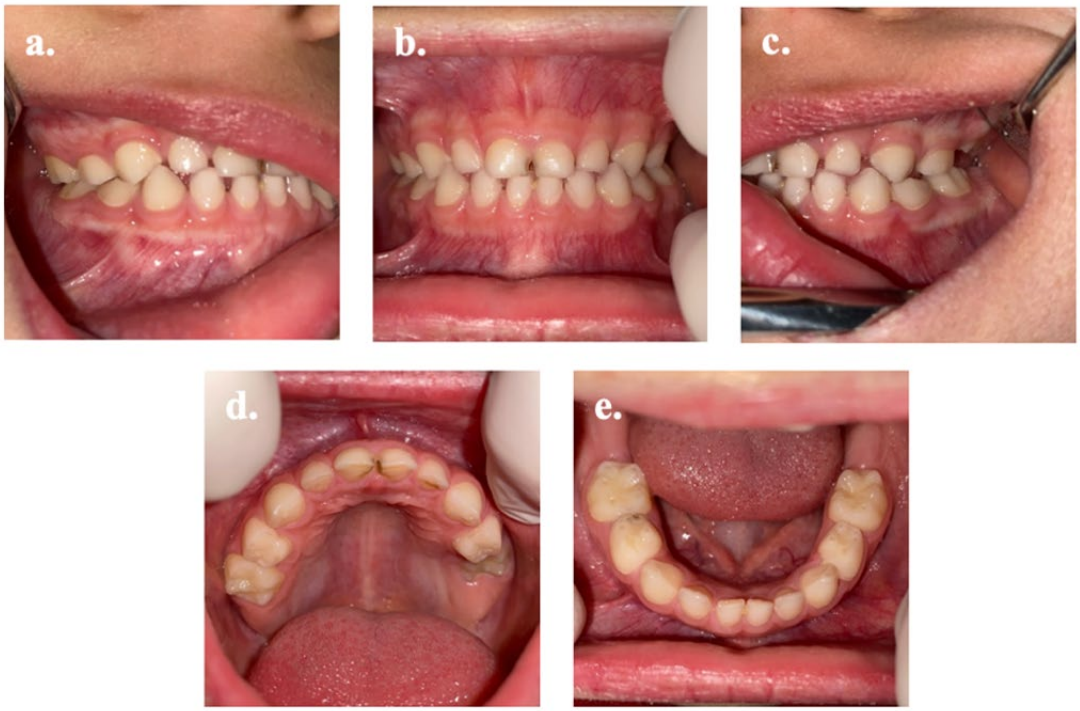

Figure 3. Intraoral photographs. a: Right lateral view; b: Frontal view; c: Left lateral view; d: Upper occlusal view; e: Lower occlusal view

Evaluation of patients by the teledentistry group

The study's dental evaluation chart is intended for practical application. The form used in the clinical examination of the patients was adapted to the mobile application system. The identity information of the patients was hidden, and the patients were uploaded to the system according to the given number order. Teleconsultant physicians used the mobile application's patient information and anamnesis tabs to access patient information (Figure 4). Using their user IDs and passwords, teleconsultant physicians accessed the database. After selecting an enrollment, each dentist reviewed the images and made their diagnosis and guidance on the condition of each tooth in a predefined rubric. The teleconsultant physicians then assessed the patients using the images and entered their results into the system. Teleconsultant physicians were also evaluated per WHO standards for oral cavity inspection.[15]

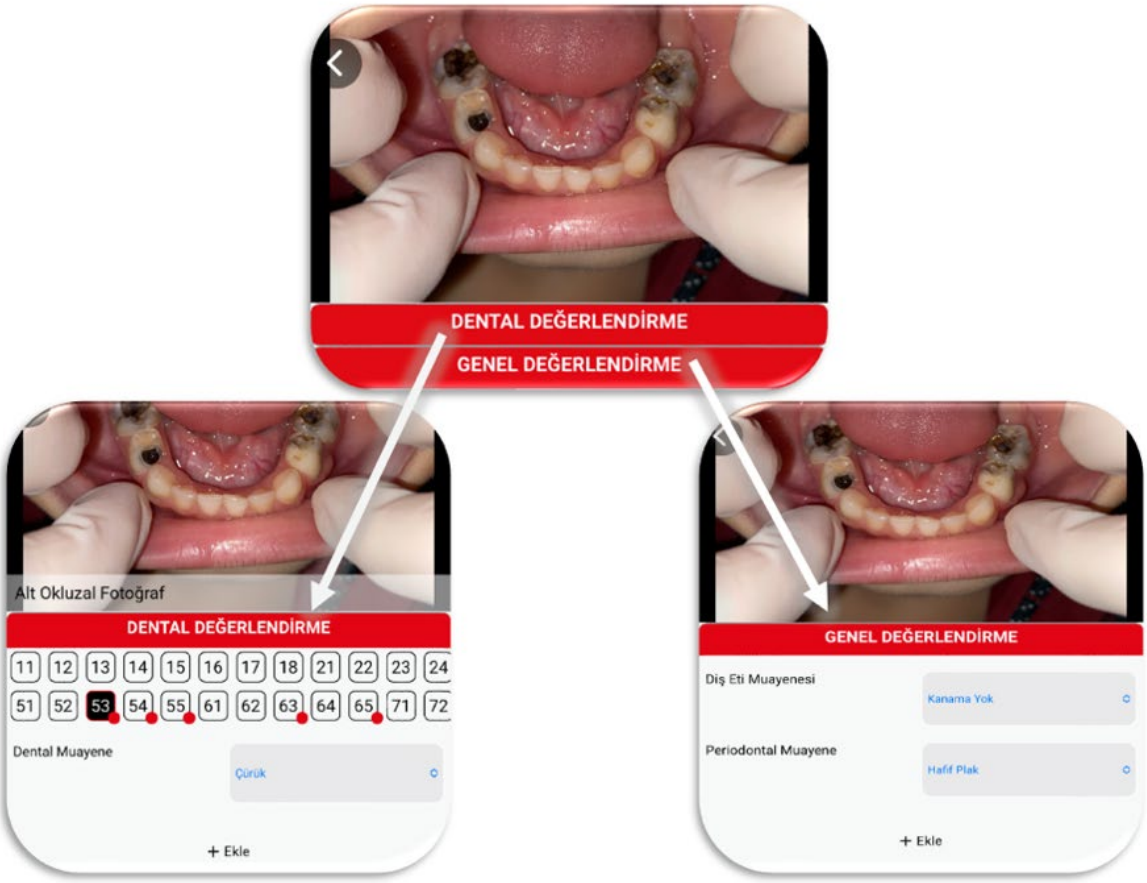

Figure 4. Patient examination screen on mobile application

RESULTS

Sample photographs were taken from 115 children aged 4 to 15 years. Among the patients included in the trial, 53.9% were female (n=62), and 46.1% were male (n=53). There was no statistically significant difference between the mean ages of the patients according to gender (p=0.422). The average age of girls was 8.50, while the average age of boys was 9.00. The average age of the sample was 9.18 years old. Table 1 displays the age distribution of the patients included in the study by gender.

Table 1. Age distribution of patients included in the study by gender.

	Mean± SD	Median (Min- Max)	Test statistic	p
Sex				
Female (n=62)	8.98 ± 3.39	8.50 (4.00- 15.00)	1500.5	0.422
Male (n=53)	9.42 ± 3.01	9.00 (4.00- 15.00)		
Total	9.18 ± 3.21	9.00 (4.00- 15.00)		

Findings of compatibility among clinicians performing face-to-face examinations

A total of 2766 teeth were confirmed and evaluated by radiographic examination by physicians who performed the face-to-face examination in the clinic, and the diagnoses were documented. Although statistically significant compatibility was found among clinicians in general, the results of clinician 1 were used when comparing the compatibility between physicians who performed face-to-face clinical examinations and physicians in the teledentistry group.

Findings of compatibility between clinicians and teleconsultant physicians

Regarding the dental examination and dental erosion in primary teeth, there was statistically significant and very good compatibility between the clinician and teleconsultant physicians ($p<0.001$). Regarding teeth examination, there was statistically significant and very good compatibility among the teleconsultant physicians ($p<0.001$). Regarding dental examination, dental trauma, and dental erosion in permanent teeth, statistically significant and very good compatibility was found between the clinician and teleconsultant physicians and between teleconsultant physicians ($p<0.001$). The compatibility of the dental examination, dental erosion, and dental trauma parameters acquired in the study between the clinician and teleconsultant examination and between teleconsultant physicians is shown in Table 2.

A statistically significant weak compatibility was obtained in terms of gingival bleeding, a statistically significant very good compatibility in terms of orthodontic examination between clinicians and teleconsultant physicians, a statistically significant good level of compatibility was obtained in terms of oral mucosal lesions status and oral mucosal lesion location. A statistically significant and very good compatibility was obtained regarding treatment referral for the patient ($p<0.001$). There was a statistically significant weak level in terms of gingival bleeding, a statistically significant moderate level in terms of periodontal status, a statistically significant very good compatibility in terms of orthodontic examination, a statistically significant good level of compatibility was obtained in terms of oral mucosal lesions status and oral mucosal lesion location. A statistically significant very good level of compatibility was obtained regarding treatment referral for the patient ($p<0.001$). The compatibility between the clinician and teleconsultant physicians and between teleconsultant physicians in terms of gingival bleeding, periodontal status, orthodontic examination, oral mucosal lesions status, oral mucosal lesion location, and treatment referral for the patient is shown in Table 3.

Table 2. Compatibility of a dental examination, dental erosion, and dental trauma parameters between clinician and teleconsultant physicians and between teleconsultant physicians for primary and permanent dentition.

		Primary dentition (n=1155)		**Permanent dentition (n=1611)**		**Total (n=2766)**	
		Fleiss' kappa	p	Fleiss' kappa	p	Fleiss' kappa	p
Clinic Physician-Teleconsultant Physician (1, 2, 3, 4, 5, 6)	Dental examination	0.865	**<0.001**	0.830	**<0.001**	0.857	**<0.001**
	Dental erosion	---	---	0.958	**<0.001**	0.766	**<0.001**
	Dental trauma	---	---	0.964	**<0.001**	0.964	**<0.001**
Teleconsultant Physician (1, 2, 3, 4, 5, 6)	Dental examination	0.864	**<0.001**	0.837	**<0.001**	0.861	**<0.001**
	Dental erosion	---	---	0.953	**<0.001**	0.953	**<0.001**
	Dental trauma	---	---	0.957	**<0.001**	0.957	**<0.001**

Table 3. Compatibility of gingival bleeding, periodontal status, orthodontic examination, oral mucosal lesions, and treatment referral parameters for the patient between clinical dentist and teleconsultant dentists and between teleconsultant dentists for primary and permanent dentition.

		Total Patients (n=115)	
		Fleiss kappa	p
Clinic Physician – Teleconsultant Physicians (1, 2, 3, 4, 5, 6)	Gingival bleeding	0.403	**<0.001**
	Periodontal status	0.458	**<0.001**
	Orthodontic examination	0.867	**<0.001**
	The situation in terms of oral mucosal lesions	0.665	**<0.001**
	Oral mucosa lesion location	0.669	**<0.001**
	Treatment referral for the patient	0.869	**<0.001**
Teleconsultant Physicians (1, 2, 3, 4, 5, 6)	Gingival bleeding	0.364	**<0.001**
	Periodontal status	0.440	**<0.001**
	Orthodontic examination	0.866	**<0.001**
	The situation in terms of oral mucosal lesions	0.660	**<0.001**
	Oral mucosa lesion location	0.663	**<0.001**
	Treatment referral for the patient	0.861	**<0.001**

The comparability of DMFT and dft indexes between primary and permanent teeth between clinical examination physicians and teleconsultant physicians were evaluated. According to the DMFT and dft index kappa scores, clinician 1 and clinician 2 had statistically significant and very good compatibility ($p<0.001$). Although the intraclass compatibility coefficient of DMFT and dft indexes between clinician 1 and clinician 2 was statistically significant and very good, the results of clinician 1 were used when comparing compliance with teleconsultant physicians. According to the kappa scores of the DMFT and dft indexes, the clinician and the teleconsultant physicians had a statistically significant and very good agreement ($p<0.001$). According to the kappa scores of the DMFT and dft indexes, there was statistically significant and very good compatibility between

the DMFT clinician and the teleconsultant physicians (p<0.001). The evaluation of the compatibility between physicians according to the kappa scores of the DMFT and dft indexes obtained in the study is given in Table 4.

To determine the sensitivity of dental examination parameters and telediagnosis, diagnostic tests were performed between clinician 1 and clinician 2. Since the results were very good, clinician 1 was accepted as a reference, and diagnostic tests were calculated separately and concurrently with teleconsultant physicians. Among teleconsultant physicians, specificity values (98.61%-99.12%) were greater than sensitivity (80.93%-96.93%). Between the clinician who did the examination and the teleconsultant physicians, there was a statistically significant very good compatibility for the parameters of the dental examination (p 0.001).

Table 5 displays the results of diagnostic tests conducted on physicians based on the study's dental examination characteristics. Regarding reactions to dental examination parameters in primary teeth, there was statistically significant and very good compatibility between the clinician and teleconsultant physicians (K=0.854; p<0.001). In terms of the replies to the dental examination parameters in permanent teeth, there was statistically significant and very good compatibility between the data of the clinician and teleconsultant physicians (K=0.860; p<0.001). The agreement between the clinician and teleconsultant physicians regarding dental examination results for primary and permanent teeth obtained in the study is given in Table 6.

Table 4. Compatibility among physicians according to kappa scores of DMFT and dft indexes.

		ICC (95% CI)	P
CP 1- CP 2	DMFT	0.983 (0.975- 0.989)	**<0.001**
	dft	0.977 (0.964- 0.985)	**<0.001**
CP 1- TP 1	DMFT	0.952 (0.928- 0.968)	**<0.001**
	dft	0.983 (0.974- 0.989)	**<0.001**
CP 1- TP 2	DMFT	0.947 (0.921- 0.965)	**<0.001**
	dft	0.977 (0.965- 0.985)	**<0.001**
CP 1- TP 3	DMFT	0.934 (0.901- 0.956)	**<0.001**
	dft	0.972 (0.957- 0.982)	**<0.001**
CP 1- TP 4	DMFT	0.923 (0.885- 0.949)	**<0.001**
	dft	0.972 (0.958- 0.982)	**<0.001**
CP 1- TP 5	DMFT	0.965 (0.948- 0.977)	**<0.001**
	dft	0.978 (0.966- 0.986)	**<0.001**
CP 1- TP 6	DMFT	0.943 (0.915- 0.962)	**<0.001**
	dft	0.967 (0.949- 0.978)	**<0.001**
CP 1 – TP (1,2,3,4,5,6)	DMFT	0.985 (0.980- 0.989)	**<0.001**
	dft	0.992 (0.989- 0.994)	**<0.001**
TP (1,2,3,4,5,6)	DMFT	0.984 (0.978- 0.988)	**<0.001**
	dft	0.990 (0.987- 0.993)	**<0.001**

** CP: Clinic Physician ** TP: Teleconcultant Physician*

Table 5. Diagnostic test results of dental examination parameters among physicians.

Dental examination	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)	Kappa (p)
CP 1 – CP 2	96.93	99.70	97.58	99.69	99.63	**0.953 (p<0.001)**
CP 1 – TP 1	91.67	99.07	94.05	99.19	98.99	**0.869 (p<0.001)**
CP 1 – TP 2	89.12	98.93	92.14	99.05	98.79	**0.844 (p<0.001)**
CP 1 – TP 3	83.24	98.76	94.39	98.91	98.65	**0.837 (p<0.001)**
CP 1 – TP 4	85.06	98.68	95.50	99.13	98.73	**0.832 (p<0.001)**
CP 1 – TP 5	88.43	99.12	93.69	99.17	98.97	**0.871 (p<0.001)**
CP 1 – TP 6	80.93	98.61	87.99	99.09	98.61	**0.836 (p<0.001)**

** PPV: Positive predictive value, ** NPV: Negative predictive value *** CP: Clinic Physician, ****TP: Teleconsultant Physician*

Table 6. Compatibility between clinical dentist and teleconsultant dentists regarding dental examination results in primary and permanent dentition.

	CP 1 (%)	TP1 (%)	TP 2 (%)	TP3 (%)	TP 4 (%)	TP 5 (%)	TP 6 (%)	Fleiss' Kappa	p
Primary Dentition									
Sound (%)	473 (45.1)	482 (45.5)	469 (44.3)	481 (45.2)	533 (50.3)	466 (44)	535 (50.5)		
Caries (%)	477 (45.5)	491 (46.4)	499 (47.1)	497 (46.7)	435 (41)	494 (46.6)	441 (41.6)		
Filled w/caries (%)	15 (1.4)	14 (1.3)	27 (2.5)	11 (1)	11 (1)	19 (1.8)	14 (1.3)	0.854	**<0.001**
Filled no caries (%)	55 (5.2)	48 (4.5)	43 (4.1)	56 (5.3)	59 (5.6)	56 (5.3)	50 (4.7)		
Caries and abscess (%)	27 (2.6)	23 (2.2)	20 (1.9)	18 (1.7)	21 (2)	23 (2.2)	19 (1.8)		
Filled w/caries and abscess (%)	1 (0.1)	1 (0.1)	1 (0.1)	1 (0.1)	1 (0.1)	1 (0.1)	1 (0.1)		
Permanent dentition									
Sound (%)	1106 (71.4)	1148 (74.1)	1161 (75.2)	1149 (73.6)	1225 (78.3)	1124 (71.9)	1185 (75.9)		
Caries (%)	312 (20.1)	269 (17.4)	252 (16.3)	278 (17.8)	211 (13.5)	308 (19.7)	244 (15.6)		
Filled w/caries (%)	13 (0.8)	12 (0.8)	16 (1)	5 (0.3)	9 (0.6)	13 (0.8)	9 (0.6)	0.844	**<0.001**
Filled no caries (%)	27 (1.7)	25 (1.6)	20 (1.3)	34 (2.2)	28 (1.8)	26 (1.7)	31 (2)		
Fissure sealant (%)	36 (2.3)	40 (2.6)	40 (2.6)	40 (2.6)	36 (2.3)	38 (2.4)	37 (2.4)		
Unerupted (%)	55 (3.6)	55 (3.6)	55 (3.6)	55 (3.5)	55 (3.5)	55 (3.5)	55 (3.5)		

DISCUSSION

While teledentistry is relatively new, current standards for evaluating its effectiveness need to be revised.[16,17] Introducing each new technology necessitates clinical testing and safety investigation.[18] Several studies have evaluated the teledentistry practice of remote dental examinations in children globally and in Turkey.[19-24] In the 2010s, there was a tremendous advancement in mobile technologies. Summerfelt[25], stated that using existing technologies, dentists can take patient data digitally and transmit it to a remote specialist dentist for triage, diagnosis, and referrals. Due to limited storage capacity and poor data transfer, smartphones in telemedicine were not warmly embraced until recently.[26] Due to smartphones' inherent digital imaging capabilities, processing power, and sharing ability, as well as their low cost and secure cloud storage access, it is anticipated that their usage in routine dental services will rise as more people acquire them.[10]

Recently, mobile health applications have been applied in various medical fields due to the widespread use of mobile devices, the low cost of internet connection, and the ability to reach almost any remote area to a large extent.[13,27] In our study, a mobile application has been developed that enables remote physicians to view the uploaded data practically and capture photographs in situations when patient contact is limited, such as geographical barriers and infectious disorders in dentistry. While most cloud environments let patient photos be store-and-forward, many prohibit capturing patient-related information such as age, medical history, and dental history. In addition, social communication networks such as Whatsapp compress the photo in their algorithm for faster file transfers and format them accordingly. This causes deterioration in transmitted image quality and clarity. With the thought application developed in our study, it was thought that developing a mobile application with the ability to examine patient findings and photographs, as well as save the referrals of distant dentists in the same patient file, could create an automatic interface format and allow all patient-related data to be uploaded at once. In addition, physicians and allied health staff can save time by taking and uploading patient photographs using a smartphone camera. The 'TeleDiş' mobile application was created in our study and put on the smartphone we used in the study for these reasons.

The scope of teledentistry is quite broad. There are studies investigating their use in orthodontics, traumatic dental injuries, and even the diagnosis of oral diseases.[18-21,28] For this reason, the mobile application we created is focused on the pediatric patient group with both primary dentition, mixed dentition, and permanent dentition.

Most studies on dental caries have utilized DMFT/dft indices to evaluate the reliability of teledentistry.[18,29-31] Although the DMFT/dft index has typically demonstrated high reliability in prior studies, this method has a disadvantage. While the DMFT/dft index is helpful for epidemiological purposes, it is not valid for diagnosis or treatment planning. The International Caries Detection and Assessment System (ICDAS) method could not be used at the scanning level because intraoral images only offer a two-dimensional picture, making it challenging to analyze the tooth surface. The presence or absence of caries is only one factor in the WHO's oral health evaluation form for children. It is a far more sensitive technique that records elements missing by the DMFT/dft index, such as fissure sealants, filled with caries, fixed dental prosthesis, and crowned teeth, and treatment choices.[20,32-34] In addition, this form is meant to be straightforward to utilize in large-scale oral health research. In order to test the sensitivity and specificity of the TeleDiş mobile application we created in our study and to determine whether findings such as abscesses, periodontal conditions, attrition, and orthodontic examination that can be

diagnosed during the face-to-face examination can also be diagnosed through the mobile application we created, the form was modified by adding these items to the WHO oral health evaluation form for children.

Photographic recordings of patients have become a popular topic in dentistry, as photography and dentistry go together for a diagnosis, treatment planning, and documentation.[35] Digital cameras are only sometimes practical due to their vast size, even though they frequently provide images of excellent quality when used correctly.[36] Although digital cameras with macro lenses provide wonderful images, they are frequently huge and cumbersome and might frighten young children. Today's smartphones are smaller, accessible to practically everyone, and usable anytime. In addition, smartphones allow easy data transfer with an internet connection and do not scare children familiar with the smartphone camera.[36] No training is necessary to utilize the many features of smartphones (zoom, flash, focusing, etc.), and they are portable and conveniently available, making them particularly handy for obtaining intraoral and extraoral images. Recent studies have demonstrated that interpreting images captured with smartphones for diagnosing oral illnesses is comparable to clinical examination.[10,14,37] However, photographic examination of intraoral findings has several drawbacks. All tooth surfaces, particularly the interproximal surfaces of the posterior teeth, are hidden from view in the pictures' two-dimensional representation. The photographic method is also limited in detecting root surface caries (until revealed by the gingival recession) or undetectable filled with caries. The two-dimensional image permits the detection of caries lesions, typically located on the occlusal surfaces of the teeth, buccal surfaces, and lingual surfaces. In our study, teleconsultant physicians diagnosed caries discoloration on the teeth surfaces, whereas clinicians investigated the discoloration on the tooth surfaces using a probe and diagnosed the teeth as sound. This data led us to believe that teleconsultant physicians analyze the discoloration of patients' teeth based on the caries risk and deem it caries at the time of diagnosis. In addition, in our study, teleconsultant physicians had difficulties identifying caries on the distal surfaces of the teeth using photographic images.

It is acknowledged that the use of radiography makes it challenging to diagnose caries since neither the face-to-face clinical caries examination method nor the photographic caries examination method can identify interproximal or non-cavitated caries lesions without radiographic images.[10] Consequently, this study aimed to evaluate the efficacy of the teledentistry strategy for dental screening using the mobile application we created rather than to estimate the prevalence of caries at the screening level using clinical methods.

In our study, clinicians examined patients separately. When the compliance of clinicians among themselves was assessed, the findings were statistically good and very good. This condition led us to believe physicians attend the same school for diagnosis and treatment planning. Clinician 1 was chosen as the gold standard due to clinicians' high level of compatibility. According to clinician 1, the compatibility of the evaluations made by teleconsultant physicians was examined.

When the literature is examined, certain studies support that intraoral evaluations conducted via teledental examination are just as reliable as in-person clinical evaluations.[29,38-41] In a study conducted by Kopycka-Kedzierawski et al.[29], it was determined that there was no significant difference between clinical examination and teledental examination in children aged 4-6 years. Images were taken using an intraoral camera. It is generally known that various dentists can produce varying diagnostic outcomes. When the study findings were examined, statistically significant and very

good compatibility was obtained between the clinician and teleconsultant physicians.A statistically significant weak compatibility was obtained between the clinician and teleconsultant physicians regarding gingival bleeding in 115 patients who participated in the study ($p<0.001$). The evaluation of gingival bleeding had our study's lowest statistically significant findings. It was thought that the explanation for this condition was because gingival bleeding determined with a periodontal probe in the clinical setting could only be analyzed photographically in terms of edema, hyperemia, and hypertrophy. When the periodontal condition was examined, it was discovered that there were significant differences in the evaluation of plaque amount across teleconsultant physicians (Table 3). It is allowed to be differences in the evaluation because the amount of plaque is a subjective scale in terms of both clinical and photographic evaluation.

Studies demonstrating the efficacy and reliability of teledentistry applications in patients' diagnosis, treatment, and follow-up are available in orthodontics when the literature is examined.[42-45] Also, researchers assessed the advantages of teledentistry in the remote management of orthodontic patient treatment. All of these studies revealed that tele-orthodontics has the potential to be helpful, but more research is necessary.[2,46-49] Additional studies analyze tele-orthodontics as a method of performing initial examinations and report that the tele-examination method can be implemented via clinical pictures in diagnosis and treatment planning.[48,50] In our study, when clinician and teleconsultant physicians were examined in terms of orthodontic examination, a statistically significant very good compatibility was established. This research indicates that patient pictures (intraoral and extraoral) are sufficient for teleconsultant physicians to detect dental and skeletal malocclusions and guide the patient.

In our study, teleconsultant physicians evaluated the patients according to their treatment needs (protective, emergency treatments, orthodontic treatment, or referral for comprehensive evaluation due to systemic diseases) after the patients' intraoral examinations. A statistically significant very good compatibility was obtained when these referrals were compared to the clinician. We believe that the high referral rates are due to the precise communication of the causes for the patients' visits to our clinic to the teleconsultant physicians in the anamnesis segment, as well as the competence and experience of the teleconsultant physicians (at least five years of experience).

According to the majority of studies, teledentistry demonstrated a good level of sensitivity and specificity.[32,51-55] In studies evaluating the compatibility between the clinical examination method, which is accepted as the gold standard, and the teledentistry method, moderate and good compatibility was found.[32,56,57] In addition, the teledentistry method's positive predictive value and accuracy rate have been reported to be relatively high.[14,32,52,55,57] In published studies on this topic, it has been noted that the sensitivity of teledentistry applications ranges from 25% to 100%, and the specificity ranges from 52% to 100%; these values are above 70% in the majority of studies.[14,32,52,53,55,57] According to our study's findings, the teledentistry method's dental evaluation method gives a high sensitivity and a very high specificity comparable to the face-to-face dental examination method. Across the two clinicians and six teleconsultant techniques, the specificity values were higher than the sensitivity values. The current model is more likely to produce false positive findings than false negative results, despite the sensitivity and specificity being over 80%. We believe the comparatively low sensitivity results from physicians' inability to recognize interface-onset caries, their inability to differentiate between caries and fissure sealants in teeth with high plaque, and their inability to diagnose filled with caries without

radiography. The teledentistry method met the WHO reference criteria of 85%–90% accuracy.[58] The sensitivity scores of the teledentistry method (83-87%) compared to the in-person clinical examination, on the other hand, were close to the WHO reference norm. Utilized within its constraints, the teledentistry methodology (in the absence of face-to-face clinical examination) provides a dependable method of remote dental screening. Our study is consistent with earlier studies testing the sensitivity and specificity of teledentistry.[20]

It should be noted, however, that in the patient population, we chose, the primary teeth remain in the mouth for a longer time, whereas the permanent teeth erupt in the mouth with age. It was found that the replies to sound teeth, caries, and filled with caries differed the most when the compatibility between the clinician and teleconsultant physicians was compared in terms of dental examination outcomes of primary and permanent teeth. While the absence of radiographs in the current teledentistry model may explain the difficulty in detecting caries, teleconsultant physicians reported a higher number of sound teeth because they could not detect non-cavitational early caries.

Concerns about the confidentiality of dental information stem from the transmission of medical histories and records and general security concerns about electronically stored information on computers.[44] Teledentistry practitioners should take the utmost care to ensure unauthorized persons do not compromise that patient privacy. Nonetheless, patients should be warned that their information will be transmitted electronically and that, despite every attempt to assure security, there is a chance that it could be intercepted.[31] Concerns regarding the correct method of informing patients about the potential transfer of their data may also emerge. Privacy and security concerns, price, financing, and taxes concerns with electronic commerce. There is no method to assure the quality, safety, efficiency, or effectiveness of information interchange worldwide and in our country. Numerous legal concerns, such as licensing, jurisdiction, and abuse of authority, have not yet been decided definitively by many states' legislatures or judicial authorities.[59] There is no explicit legal rule regarding the indemnification of damages or complaints that may arise during telemedicine and teledentistry treatments in Turkey, so it is unclear who is liable.[60]

Due to the lack of interaction between dentists and patients, a patient-physician relationship could not be developed in the teledentistry group, another disadvantage of our study. As the pedodontic treatment triangle requires, physicians must have a healthy relationship with parents and children to provide effective dental treatment for children. This must be further incorporated into teledentistry programs.

CONCLUSIONS

It has been demonstrated that the combination of the store-and-forward method and a smartphone camera provides a valid and reliable remote scanning method for evaluating intraoral findings at the mobile application level. The mobile teledentistry concept has considerable promise for rural or remote populations with limited dental care facilities. At the screening level, GPs, nurses, and even non-licensed allied health staff, such as teachers or caretakers, can remotely generate digital data (dental photographs) for subsequent evaluation by a dentist. This strategy may give a method for identifying patients for whom referral for dental treatment is unnecessary or for prioritizing those who require immediate evaluation by a dental professional. To overcome current constraints and enhance the diagnostic performance of the teledentistry technique, better-designed research is required.

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