2023

Diagnostic Outcomes of Digital Images for Comprehensive Examination in Pediatric Dentistry: An Intraexaminer Agreement Assessment

Maria Fernanda Montoya
University Of Alabama At Birmingham

DIAGNOSTIC OUTCOMES OF DIGITAL IMAGES FOR COMPREHENSIVE EXAMINATION IN PEDIATRIC DENTISTRY: AN INTRAEXAMINER AGREEMENT ASSESSMENT

by

MARIA FERNANDA MONTOYA

NOEL CHILDERS, COMMITTEE CHAIR
NATHANIEL LAWSON
STEPHEN MITCHELL
PING ZHANG

A THESIS

Submitted to the graduate faculty of The University of Alabama at Birmingham,
in partial fulfillment of the requirements for the degree of
Master of Science

BIRMINGHAM, ALABAMA

2023

DIAGNOSTIC OUTCOMES OF DIGITAL IMAGES FOR COMPREHENSIVE EXAMINATION IN PEDIATRIC DENTISTRY: AN INTRAEXAMINER AGREEMENT ASSESSMENT

MARIA FERNANDA MONTOYA

DENTISTRY

ABSTRACT

Purpose: To Assess intra-examiner diagnoses obtained via traditional oral clinical examination (TCE) versus digital oral examination (DOE) completed from digital video images of pediatric patients. **Methods:** Fifty pediatric patients 5 to 10 years of age, who attend the Pediatric Dentistry Clinic at the University of Alabama at Birmingham (UAB) for initial consultations or regular visits were included in this study. Individual oral comprehensive examinations were done by five second-year pediatric dentistry residents. A trained dental hygienist recorded a full mouth intraoral video for each patient via MouthWatch intraoral camera and stored using existing Information and Communication Technology (ICT) infrastructure. After a one-month wash-out period, videos were assessed by the same examiner for comprehensive evaluations. Intra-examiner consistency (percent) and examiner agreement was determined using the kappa coefficient (95% confidence interval [CI]). **Results:** The overall findings indicated 93.5% intra-examiner consistency (C) and a moderate to almost perfect agreement between DOE and TCE with a kappa coefficient of 0.85 (0.73-0.95). The highest agreement was dental caries detection (k=0.89) and assessment of hard tissues (k=0.93) The lowest agreement was on assessment of dental occlusion (k=0.64), followed by assessment of oral hygiene (k=0.82). **Conclusions:** Dentists make similar diagnoses via DOE and TCE when examining school-age children. Within the limitations of the current study, the oral video record was found to be comparable to traditional visual clinical examination for the diagnosis of dental problems among school children, with both producing good and reproducible diagnostic outcomes. These findings support the use of the DOE as an alternative method of providing oral examination, assessment, and diagnosis for school aged children.

Keywords: Intraoral camera, Intra-examiner agreement, Pediatric dentistry, Remote diagnosis, Teledentistry

DEDICATION

To my husband and my daughters, for their continuous support and understanding while undertaking my research. Their patience and prayers sustained me this far.

To God, for letting me through all the difficulties.

ACKNOWLEDGMENTS

I would like to give my thanks to my primary mentor, Dr. Childers for his guidance, continuous support, and patience through all the stages of doing research and writing my project.

Foremost, I would like to express my sincere gratitude to Dr. Mitchell for creating this project, and for his continuous motivation, enthusiasm, and immense knowledge shared all throughout the process of my research.

I also like to express my sincere gratitude to my thesis committee members, for their support, time, feedback, and guidance.

Thanks Sherry Campbell, for your encouragement, and for always being available to make this project possible.

To my dear second-year co-residents, thank you for your endless support and encouragement as well as for participating in the project as examiners. I appreciate the non-biased feedback attained allowing me to complete the study.

I wish to thank the Department of Pediatric Dentistry of The University of Alabama at Birmingham, for providing the resources and facilities to perform this study.

Last, but not least, I would like to extend my sincere gratitude to Dr. Morales and Dr. Li for support me in the statistical analysis.

TABLE OF CONTENTS

Contents Page

ABSTRACT.......... iii

DEDICATION.......... v

ACKNOWLEDGMENTS vi

TABLE OF CONTENTS.......... vii

LIST OF TABLES.......... x

LIST OF FIGURES xi

LIST OF ABBREVIATIONS.......... xii

CHAPTER 1 INTRODUCTION 1

Telemedicine 1

Teledentistry.......... 2

Modalities of Teledentistry.......... 3

Teledentistry in the United States.......... 4

Teledentistry in Alabama.......... 5

Scope of Teledentistry 5

Technological Requirements to Practice Teledentistry 6

Advantages and Limitations of Teledentistry.......... 6

Applications of Teledentistry 8

Use of Teledentistry in Different Dental Specialties 10

Oral Diagnosis 10

Oral Radiology 11

Pediatric and Preventative Dentistry 11

Orthodontics and Dentofacial Orthopedics 11

Endodontics 12

Oral Medicine 12

Periodontics 13

Oral and Maxillofacial Surgery 13

Prosthodontics 13

Dental Education 14

Research Problem 14

General Objective 15

Specific Objectives 15

Hypotheses 16

CHAPTER 2 MATERIALS AND METHODS 18

Bioethical Committee Approval 18

Sample Selection 19

Data Collection 20

Data Transmission 21

Research Procedures 21

Phase 1. Protocol Development and Calibration of Data Collectors 21

Phase 2. Intraoral Comprehensive Examination and Intraoral Video Record 22

Phase 3. Telediagnosis 23

Phase 4. Comparative Analyses 23

Statistical Analysis 24
CHAPTER 3 RESULTS 26
Description of the Sample 26
Overall Agreement on the Assessment of Oral Conditions 27
Overall Agreement on the Screening for Dental Caries 28
Agreement on the Detection of Dental Caries in Primary Teeth 28
Agreement with Caries Detection in Permanent Teeth 32
Agreement on the Hard Tissues Assessment 37
Agreement on the Assessment of Oral Hygiene 38
Agreement on the Evaluation of the Dental Occlusion 39
CHAPTER 4 DISCUSSION 41
CHAPTER 5 CONCLUSION 53
REFERENCES 55
APPENDIX A 67
IRB APPROVAL 68
APPENDIX B 69
WHO DENTAL CHART MODIFIED FORM 70

LIST OF TABLES

Table Page

Table 1 Description of the sample.. 26

Table 2 Overall agreement on the Assessment of Oral Conditions 27

Table 3 Overall Agreement on caries detection in primary teeth 28

Table 4 Agreement on caries detection in primary posterior teeth 30

Table 5 Agreement on caries detection in primary anterior teeth 32

Table 6 Agreement on caries detection in permanent teeth 33

Table 7 Agreement on caries detection in permanent posterior teeth 35

Table 8 Agreement on caries detection in permanent anterior teeth.................................. 37

Table 9 Agreement on the hard tissues assessment... 38

Table 10 Agreement on the assessment of soft tissue and oral hygiene 39

Table 11 Agreement on the evaluation of the dental occlusion 40

LIST OF FIGURES

Figure Page

Figure 1. Agreement on the detection of dental caries primary teeth 29

Figure 2 Agreement on the caries detection in primary anterior teeth 31

Figure 3. Agreement on caries detection in permanent posterior teeth 33

Figure 4. Agreement on caries detection permanent anterior teeth. 36

LIST OF ABBREVIATIONS

AAPD	American Academy of Pediatric Dentistry
C	Consistency
CDHC	Community Dental Health Coordinator
CI	Confidence interval
DMFS	Decay, missing, and filled teeth surfaces in permanent teeth.
dmfs	Decay, missing, and filled teeth surfaces in primary teeth.
FDA	Food and Drug Administration
ICT	Information and Communication Technology
IRB	Institutional Review Board for Human Use
k	Kappa
PDC	Pediatric Dentistry Clinic
UAB	The University of Alabama at Birmingham

CHAPTER 1

INTRODUCTION

Telemedicine

Telemedicine is defined as the exchange of medical data from one site to another via electronic communication [1–4]. It consists of the use of digital information and communication technology (ICT) to provide healthcare assistance when medical specialist-patient face-to-face consultation is not feasible [1,2,5,6]. For decades, it has been used in a variety of medical specialties for consultation, diagnosis, and treating diseases [1–3,7] and for medical education [8,9].

Telemedicine has been evaluated in different programs in the US, as it is helpful to provide healthcare access to remote and rural communities, where specialist consultation is not possible [7,10,11]. Previous studies have found multiple benefits of telehealth, namely improvement of access to health care, referrals, earlier diagnosis and treatment, cost-saving, reduction of unnecessary consultations, and increment of remote medical specialist consultation [1,2,5,6,12–14].

Teledentistry

Even though telemedicine has been used in different medical specialties for decades, its practice is not widely accepted in dentistry [10,13,15,16]. Teledentistry could be defined as a branch of telemedicine (telehealth and dentistry), which consists of the use of ICT to transmit oral health information and support oral healthcare delivery [4,7,17,18]. It has been implemented to provide oral health care for children [19–22], dental education [8,9], specialist clinical practice [19–22], information synthesis, and medical research [23].

Sengupta et al. [24] and Mariño and Ghanim [4] describe teledentistry as a branch of dentistry that combines dental practice and the use of ICT, integrates electronic health tools and telecommunications to exchange clinical information that facilitate the provision of remote oral diagnosis, treatment planning, and even delivery of healthcare for the prevention and treatment of oral diseases and dental trauma. Torres et al. [25] and Mariño and Ghanim [4], stated that teledentistry enables the transmission of synchronous or asynchronous clinical information using electronic health records, telecommunication technology, video, and digital images to increase access to dental services, especially for those patients who live in distant, isolated, rural [24,26–28], and underserved areas [29–32], and enhance communication among dental specialists, dental assistants, and medical professionals that is not restricted to space and time [15,33,34].

Although teledentistry was originally developed and is associated with the provision of oral care in rural or remote areas [24,26–28,32], its use in urban contexts in different dental specialties has increased [35–38] and, most recently, as a response to the COVID-19 pandemic, in teleconsultation, teletriage, telemonitoring, and remote dental education [8,9,17,39,40]. In both urban and rural contexts, teledentistry provides multiple potential benefits, such as identifying high-risk populations, referral of patients to a dental specialist consultation, reducing waiting times for care, and preventing unnecessary dental visits [18,37,41]. This can result in cost reductions for patients, providers, and support entities (i.e., insurance companies and government agencies) [18,37,41,42].

Modalities of Teledentistry

Four modalities of communication between patient-dentist, dentist-dental assistant, dentist-medical doctor, and among dentists have been reported [61]:

Asynchronous teledentistry. The transmission of patients' clinical data is not used in real-time, but they are stored and shared later. It involves the exchange of clinical information and images collected and stored by caregivers, dentists, and dental assistants, who sends them to a dental specialist for consultation and treatment planning. In this modality, patients are not present during the consultation [20,24,25,33,37,62–65].

Synchronous teledentistry. Synchronous teledentistry uses real-time interactive technologies such as video and videoconferencing between dentists, dental assistants, medical doctors, and patients at different locations. They can see, hear, and communicate with each other [20,24,25,33,37,62–65].

Remote monitoring of oral health care (or mobile health care services). This modality includes the use of technology such as apps for smartphones and text messages to manage and follow-up on patients' dental health conditions and promote healthy habits [24,37,40,66–68].

Near-real-time consultation. Near-real-time consultation involves the use of low-resolution and low-quality equipment that has minimal or no practical use in dentistry [37].

Teledentistry in the United States

Since 1989, when the term ‘‘teledentistry’’ was first introduced, some teledentistry programs have been developed for remote consultation, diagnosis, prevention, referral, and treatment of oral diseases and dental problems in the different dental specialties in the United States [15,16,20,38,42–45]. In 1994, the US Army was the first institution that developed teledentistry projects in the US and this program proved that teledentistry can provide oral health care and offering remote consultations [15,20,46–48]. Nichols [42] reviewed teledentistry programs developed in the US and found that the application of teledentistry has increased due to the approval of teleconsultation by the public health systems and Medicaid programs. Estai et al. [18] reported the successful experience of the Dental Health Aide Therapists program in providing access to oral health care in Alaska. Kopycka et al. [20] assessed the exploratory applications of teledentistry at the Eastman Institute for Oral Health (EIOH), University of Rochester. Their findings demonstrated that teledentistry is a practical and cost-effective way to provide oral health care for children from rural and disadvantaged areas. Langelier et al. [15] described six programs of teledentistry consultation developed by six organizations to increase access to oral health services in Colorado, Georgia, Minnesota, New York, and Oregon. Wacloff and Tang [16] analyzed the development of the teledentistry program of the Arizona Department of Health Services Office of Oral Health. Glassman et al. [49] analyzed the "virtual dental home" as an innovative strategy that could contribute to solving the US healthcare system problems by reducing costs and disparities in oral health access and oral care. Fricton and Chen [31] described the teledentistry network developed at the University of Minnesota School of Dentistry to link medical specialists to dentists, dental staff, and patients in remote rural communities where access to specialized care is not possible. Summerfelt [50] described an innovative teledentistry-assisted dental hygiene model for dental hygienists at Northern Arizona University.

Teledentistry in Alabama

In the State of Alabama, there are no regulations governing the practice of teledentistry. Furthermore, a licensed dentist must provide direct supervision for Alabama dental hygienists, meaning they are required to be physically present at all services hygiene services. This seemingly limits the ability for a dentist to use tele-dentistry in Alabama to expand the reach of his/her professional services and expertise into remote and underserved communities. In addition, third party payers do not consistently reimburse for teledentistry examinations.

Scope of Teledentistry

Evidence supports teledentistry as a cost-effective, fast, and accurate model that improves access to oral health care for children in rural and vulnerable communities [31,32,37,45,51–54]. It has been used successfully in cleft lip and palate patients [55,56], adolescent offenders in Brazil [57], children in socially disadvantaged and underserved communities [31,32,50,58,59], and children from remote and hard-to-reach rural communities [28,51,53] that lack of dentist and/or dental specialist. Finally, teledentistry has also been used in urban and suburban communities to increase access to specialized consultation provided at lower costs [35–38,60].

Technological Requirements to Practice Teledentistry

The application of teledentistry in dental procedures requires some technological devices including software and hardware [20,24,25,33,37,62–65]:

Teledentistry software. Different computer programs are required to implement teledentistry. A local area network (LAN, known as the intranet), a wide area network (WAN, known also as the internet), or satellite internet access are needed for delivering data. To protect the privacy and security of the clinical records, a security system is required [69]. Applications such as social networks, videoconferencing systems (Teams, Skype, Zoom, etc.), email, WhatsApp, iTeethey™, Remote-I, mobile microscope, digital fluorescence (QLF-D), and the Soprocare camera ™ have been successfully used in teleconsultation [24,37,70]. Most studies [13,35,36,57,60,71–75] successfully implemented digital instruments such as the Nomad Handheld X-Ray System ™, Televere's Tiger View Professional package, and DICOM (digital imaging and communications in medicine).

Teledentistry equipment. Some technological devices are desirable for practicing teledentistry. Previous studies have proved the effectiveness of the use of mobile devices, intraoral cameras, conventional telephone systems, digital network services, smartphones, portable x-rays, a desktop or laptop computer (with microphone, headset, speakers, and web camera), an intraoral video camera, a scanner, and a printer [13,35,75–79,36,57,60,65,71–74].

Advantages and Limitations of Teledentistry

Advantages of teledentistry. Some advantages of teledentistry have been identified in previous studies [7,20,37,38,49,53,69,70,80,81]:

a) It can reduce the disparities in oral health care between rural and urban areas. It could also close the gap between the demand for oral health care and the care provided.

b) It can improve oral health care for patients in remote areas.

c) As oral health care providers have access to the internet, medical records can be sent to remote sites for analysis, diagnosis, referral, and treatment recommendations.

d) Children do not need to be taken to the office for a consultation unnecessarily.

e) Parents can minimize time waiting for or commuting to appointments by remotely taking their children for consultation.

f) It is easy to track children to determine if a specialist or emergency consultation is needed.

g) It is easy for dental assistants or residents to contact the dentist specialist for further evaluation.

h) Teledentistry saves time and costs of consultation and improves access to oral health care.

Limitations of teledentistry. In contrast, the use of teledentistry may also imply some limitations that members of the dental staff, medical specialists, and patients should know [7,20,82,37,38,49,53,69,70,80,81]:

a) Legal issues, namely licensure, malpractice, privacy, data security, ethics, informed consent, and fiscal, taxation, and reimbursement issues may differ from one state to another. Therefore, the dental team must be careful when consulting with patients across state lines.

b) As dental practice depends on technologies, technical problems may affect data transmission which, consequently, could cause a misdiagnosis, medical error, or malpractice.

c) Privacy and security may be affected when using teledentistry. Patient's medical records stored in the cloud, computers, or transmitted by electronic means could be stolen or lost. Therefore, the use of a security system seems to be mandatory.

d) Teledentistry can only be used in preventative, diagnostic, and follow-up procedures. For clinical treatment, such as restorations and surgical procedures, patients must still be seen in-person at a dentist's office or dental hospital.

e) When using an intraoral camera, it may not be possible to visualize all the sides of the teeth or to identify immature plaque. In those cases, conventional examinations may be needed.

Applications of Teledentistry

The available clinical evidence on the use of teledentistry in pediatric dentistry has proved its effectiveness for diagnosing and treating oral conditions such as tooth decay, periodontal diseases, oral precancerous lesions, and malocclusion, providing access to oral health for remote, rural, and underserved populations, improving the quality of oral care, referring to dental specialties, and reducing the economic costs of treatments. Additionally, different security systems have been developed to protect the privacy of the patient's medical records. However, teledentistry is not yet an essential part of dental practice.

Recent reviews have assessed and synthesized the available evidence on the effectiveness of teledentistry for remote screening, diagnosis, consultation, treatment planning, monitoring patients, and mentoring dental staff [24,26,37,42,83]. These results indicate teledentistry can be successfully be used in different dental specialties for remote oral examination, diagnosis, consultation, and planning treatment, especially for rural, underserved populations.

Mariño and Ghanim [10], Daniel et al. [84], and Madrid et al. [52] assessed the impact of the application of teledentistry in urban and rural areas. Their results indicate that teledentistry may reduce healthcare inequalities and improve access to specialist oral healthcare consultation where it is not feasible. Estai et al. [18,85], Meurer et al. [26], and Alabdullah and Daniel [86] assessed the diagnostic accuracy and validity of teledentistry in the detection of dental caries and oral diseases. Their findings indicated that the diagnostic performance of teledentistry in the detection of dental caries is good. Its accuracy and reliability could be comparable to face-to-face oral screening. Dulieu [45] synthesized the scientific evidence on the use of teledentistry to provide preventative dental care to children in US rural communities. Estai et al. [18] analyzed the benefits of incorporating teledentistry into routine oral health care services. Their evidence supports the cost-effectiveness and clinical efficacy of teledentistry in providing oral health care in pediatric dentistry, orthodontics, and oral medicine. Daniel and Kumar [7,84] explored the clinical application and cost-effectiveness of teledentistry and proved that is an effective and cost-saving procedure for screening and diagnosing oral diseases and dental problems. More recently, Fortich and Hoyos [87] analyzed the impact of the use of teledentistry on clinical practice in different dental specialties in rural areas. Their findings show that teledentistry could be considered an alternative method to diagnose and treat oral diseases in rural and urban areas.

Use of Teledentistry in Different Dental Specialties

Teledentistry has been successfully used for patient screenings [13,14,35,36,88], specialty consultations referrals [41,80,89,90], oral health education [8,9,17,39,40], and emergency care in various dental specialties [11,91,92].

Oral Diagnosis

Some clinical studies have proved the efficacy, accuracy, reliability, sensitivity, and specificity of teledentistry for remote diagnosis of oral diseases and dental problems in children to improve their oral health status [13]. Kopycka et al. [35,36,60,71], Namakian et al. [72], and Subbalekshmi et al. [73] performed clinical studies to assess the diagnostic accuracy of teledentistry for caries detection in children and Castro et al. [57] in adolescent offenders at a Brazilian juvenile detention center. Daniel and Kumar [34,74] compared the accuracy of dental caries identification by dental assistants and dentists using clinical and teledentistry examinations. Pentapati et al. [75], and McLaren et al. [14,51] assessed the reliability of videos captured by an intraoral camera in the screening of oral diseases in children. The overall results have proved that intraoral photographic and video assessment has sensitivity and specificity for diagnosing oral diseases and dental caries in children. Therefore, the use of teledentistry for oral screening seems to be as accurate as visual face-to-face oral examinations.

Oral Radiology

Teleradiology uses network technologies and specialized software to transmit images allowing radiologists, dentists, and physicians to analyze images and inform the diagnosis. Records from clinical examinations and diagnostic tests can be shared by different means [2,44,93].

Pediatric and Preventative Dentistry

Teledentistry is a good tool for screening dental problems. It could be well suited for children, as they like to see their teeth on the computer screen [37]. Using an intraoral camera or a smartphone, dentists can detect caries and other oral diseases before they become emergencies and help children in the oral management of chronic diseases, and provide urgent care by remote visual examination [28,37,65,81,94]. Based on remote diagnoses, children can be classified according to their level of risk. Therefore, preventative programs can be developed [14,35,37,45,60,71,83].

Orthodontics and Dentofacial Orthopedics

When orthodontic consultation is not available and patient referrals are not possible, general dentists can provide interceptive orthodontic treatments. Using teledentistry, orthodontists can assist in early diagnosis, treatment planning, and follow-up supervision [32,37,41,80,89,90,95,96]. Teledentistry may provide fast access to orthodontic consultation, is effective to treat malocclusions, and reduces unnecessary referrals. Additionally, a orthodontist consulting via teledentistry could order pre-orthodontic procedures such as extractions and impressions for the study model, thereby saving time and the number of visits required for the patient to go to the orthodontist's office in-person.

Some previous studies [41,56,89,90,95,96,101] assessed the accuracy and effectiveness of orthodontic services provided by a general dentist to children with remote supervision from an orthodontist using teledentistry. Their findings indicated that interceptive orthodontic treatments provided by general dentists and supervised by orthodontic specialists using teledentistry can reduce the severity of malocclusions.

Additionally, teledentistry has been used to provide services for children with cleft lip and palate. Teoh et al. [55] and Mariño et al. [56] assessed the effectiveness of teledentistry in delivering specialist consultations vs. standard clinical consultations for patients with CLP. They found that teledentistry is a cost-effective alternative compared with the standard face-to-face consultation for CLP patients; therefore, it can improve access to specialist care for CLP patients, avoid inappropriate referrals, and reduce waiting lists for specialist consultation.

Endodontics

Remote diagnosis of the root canal and periapical problems can be reached by analyzing images prepared by general dentists and sent to an endodontist or by videoconferencing. It may reduce costs implied in the specialist consultation and, when necessary, treat emergencies [22,37,81,97].

Oral Medicine

Images of oral lesions prepared by general dentists can be sent to a specialist who can make the diagnosis of oral diseases and provide a treatment plan. Perdoncini et al. [98] evaluated the feasibility and accuracy of synchronous tele-consultation in oral medicine and found that it can be a reliable remote diagnostic method of oral lesions. Follow-up of patients after invasive treatments can also be conducted via videoconferencing.

Additionally, when necessary, based on the information provided by the images, patients can be referred to an appropriate dental specialist consultation [18,37,62,70].

Periodontics

Using an intraoral camera, high-quality images of the patient's mouth could permit a periodontist to diagnose and plan treatment for periodontal diseases. Periodontists can monitor their patients who have had periodontal surgery using digital clinical photographs and radiographs prepared by general dentists or by videoconferencing [37].

Oral and Maxillofacial Surgery

As there are not enough oral surgeons in remote areas, teledentistry could be an effective method to refer patients for oral and maxillofacial surgery consultation. This procedure can be used in the differential diagnosis of impacted third molar by dentists and oral surgery specialists [37]. To make decisions about the appropriate medical and surgical intervention, dental specialists can discuss with the general surgeon by videoconferencing, which is an effective and cost-saving procedure [78,99]. Besides, oral surgeons can monitor the patient's condition after surgical interventions.

Prosthodontics

Using teleconferencing with general dentists or based on images, prosthodontists can diagnose and plan the treatment for patients from rural areas that require oral rehabilitation [37,100]. They can evaluate edentulous ridges, supporting tissue structures, and abutment teeth using clinical photographs and radiographs prepared by general dentists or by videoconferencing.

Dental Education

The application of teledentistry includes patient, dental assistant, hygienist, and dentist education [8,9,11,17,39,40]. Chen et al. [11] identified three modalities of teledentistry education, self-instruction, dental chat rooms, and interactive videoconferencing, being the latter the strategy that has shown better results, as it can provide immediate feedback to the participants.

Web-based self-instruction. Web-based self-instruction includes activities and contents that have been developed and stored to be used at any time later. Learners can pace their learning process and access the teaching material whenever and as many times as they need [11].

Interactive videoconferencing. Teledentistry has proved to be a good strategy for teaching undergraduate and postgraduate dental students, and for continuing education for general and specialist dentists. The real-time interaction and the possibility of immediate feedback between instructors and trainees have had positive effects in pediatric dentistry, orthodontics, periodontics, dental radiology, and imaging [8,9,11,17,39,40].

Dental chat rooms. The dental chat room is a less formal strategy that the staff of dental schools and dental organizations have created to share information and discuss different clinical, educational, and research topics [11].

Research Problem

Currently, the Dental Practice Act in the State of Alabama has no provision allowing or regulating teledentistry [102]; therefore, scientific clinical evidence is needed to support laws that legalizes and encourages teledentistry practices [102]. Identifying the diagnostic accuracy, reliability, and agreement of oral examination using an intraoral video camera has the potential to improve oral health care access in Alabama, especially for patients in rural, remote, and underserved urban areas where face-to-face specialist dental services are not available [103].

As described above, the literature presents supportive data that indicates teledentistry is useful for aspects of the practice of dental specialties. However, to date, no study has assessed the implementation of teledentistry for oral diagnosis using an intraoral video camera of a comprehensive oral examination in children; therefore, this study is the first attempt to compare the dental diagnostic outcomes obtained from face-to-face comprehensive oral examination to the oral diagnosis based on digital media records in a pediatric dental clinic.

General Objective

This research project aims to assess the intra-examiner agreement of the diagnostic outcomes from the comprehensive oral examination using intraoral video records compared to the diagnostic outcomes of a standard direct clinical comprehensive examination by pediatric dental residents.

Specific Objectives

1. To assess the intra-examiner diagnostics agreement based on intraoral video records of a dental examination compared to the standard clinical examination for the diagnosis of dental caries.
2. To assess the intra-examiner diagnostics agreement based on intraoral video records of a dental examination compared to the standard clinical examination for the evaluation of hard tissues (enamel defects, erosion, attrition, and staining).

3. To assess the intra-examiner diagnostics agreement based on intraoral video records of a dental examination compared to the clinical standard examination for the assessment of soft tissues and oral hygiene status.
4. To assess the intra-examiner diagnostics agreement based on intraoral video records of a dental examination compared to the standard clinical examination for the evaluation of dental occlusion.

Hypotheses

This research proposal tested the following general hypothesis:

The oral screening based on intraoral video records offers comparable diagnostic performance to the traditional visual approach.

Furthermore, this study tested the following specific hypotheses:

1. The diagnostic performance of a telediagnosis oral examination using intraoral image records is comparable to the clinical examination for the diagnosis and evaluation of dental caries.
2. The diagnostic performance of a telediagnosis comprehensive oral examination using intraoral image records is comparable to the clinical examination for the diagnosis and evaluation of hard tissues (enamel defects, erosion, attrition, and staining).
3. The diagnostic performance of a telediagnosis comprehensive oral examination using intraoral image records is comparable to the clinical examination for the diagnosis and evaluation of soft tissue/oral hygiene status.

4. The diagnostic performance of a telediagnosis comprehensive oral examination using intraoral image records is comparable to the clinical examination for the diagnosis and evaluation of dental occlusion.

CHAPTER 2

MATERIALS AND METHODS

Bioethical Committee Approval

The UAB Institutional Review Board for Human Use (IRB) is a committee established under federal regulations for the protection of human subjects in research. Its purpose is to help protect the rights and welfare of human participants in research conducted under the auspices of the University of Alabama at Birmingham. The study protocol was submitted to and approved by the University of Alabama IRB Committee before the study begins. All the parents or caregivers of the participants received written information about the study before voluntarily deciding to take part in the study. Besides, informed consent was obtained from parents or legal caregivers. The UAB IRB requires principal investigators and all other research team members to complete and document appropriate training in the protection of human subjects. The principal researcher is a Third-year resident of the pediatric dentistry program. This study is part of the fulfillment of the master's requirement.

Sample Selection

This is a prospective study that compares the already established face-to-face oral examination method used at the Pediatric Dental Clinic, University of Alabama at Birmingham School of Dentistry, to an intraoral video assessment method in 5-10-year-old children. The sample was made up of 50 patients who attended the Pediatric Dental Clinic at the UAB School of Dentistry, Birmingham, for regular recall visits or initial consultations.

This sample size is appropriate considering similar previous studies which successfully analyzed diagnostic outcomes of teledentistry approaches with smaller or similar sample sizes. The following are examples of studies that have been completed: 10 patients to assess the agreement between remote diagnoses derived from intraoral scans and diagnoses based on clinical face-to-face examination [104], 13 patients to evaluate the feasibility of establishing a teledentistry approach to non-traumatic dental emergencies [92], 30 children to evaluate the feasibility of a general dental practitioner providing interceptive orthodontic services using teledentistry [95], 40 patients to compare the levels of inter-examiner diagnostic agreement of traumatic dental injuries of face-to-face diagnoses and diagnoses conducted remotely [105], 50 images of endodontically accessed teeth acquired with an intraoral camera [97], 50 preschool children to assess the feasibility and reliability of using an intraoral camera and telehealth communication technology to screen for early childhood caries [71].

Participants in this study were required to meet the following inclusion criteria:

- Patients aged between 5 and 10 years.

- Healthy patients that are due for 6 months recall dental visits or new patients who receive a comprehensive dental examination.
- Cooperative patients for intraoral exam, video exam, and any clinically necessary radiographic examination.

Before starting the study parents or caregivers of the children included in the research received information about the scope and the rationale of the study. Informed consent was obtained from the parent/guardian and assent from the patient.

Data Collection

Examinations were performed consistently according to clinical standards of the UAB Pediatric Dental Clinic. In this regard, second-year pediatric dentistry residents were chosen to participate as examiners because of their one-year experience in the program. Furthermore, to standardize, as second-year residents transition into teaching dental students, they were trained and calibrated. Each of five second-year pediatric dentistry residents evaluated ten patients.

At the conclusion of the clinical examination, a full mouth intraoral video of the oral cavity was obtained for each child by a trained dental hygienist and the primary research resident. The digital intraoral camera MouthWatch® (MouthWatch LLC, Metuchen, NJ) with a focal range of 5 mm-45 mm, 6 white LED lights, and a resolution of – 640 x 480 Pixels, which is registered by the FDA, was used to obtain an intraoral video from each of the children included in the study. After one month the intraoral videos were assessed by the same resident who performed the face-to-face clinical examination.

Data Transmission

After the oral examination, intraoral digital videos and periapical radiographs of each patient were stored in a UAB encrypted computer laptop Edition: HP®, version: 21H1, Windows 10 for subsequent evaluation.

Research Procedures

This study was developed in four phases:

Phase 1. Protocol Development and Calibration of Data Collectors

In this phase, a Community Dental Health Coordinator (CDHC) who was a registered dental hygienist, and the principal researcher who was a third-year pediatric dentistry resident, tested two devices for capturing intraoral videos to find good quality, and reproducible diagnostic videos. Protocol/technique for obtaining the video as well as the length of videos required to carry out the comprehensive examination were created by the CDHC and the principal researcher by a trial-and-error method with at least ten patients, five patients each. These records were assessed to determine if the digital media were appropriate. If not, the protocol was modified, another five patients were digitally documented, and the digital media were assessed again until obtaining the appropriate records.

The final protocol for digital records was as follows: Teeth were dried with 3-way air syringe or 2X2 gauze. Digital imaging records were labeled with the patient's ID numbers, gender, and age. The digital record included:

1) the patient´s smiling.

2) maxillary occlusal/lingual surfaces starting in Upper right moving to Upper Left quadrants.
3) mandibular occlusal/lingual surfaces starting in Lower Left and moving to Lower Right quadrants.
4) the patient closing and swallowing, all buccal surfaces.

Phase 2. Intraoral Comprehensive Examination and Intraoral Video Record

Each participant was assigned a unique study identification code allowing their records to be disassociated from their protected health information and facilitate the tabulation of data and ensure the privacy, anonymity, and confidentiality of patients and their parents in all the stages of the research process.

Five pediatric dentistry residents examined 10 patients each. To complete the comprehensive clinical oral examination, patients were examined in the dental chair with adequate lighting and a dental air syringe. Clinical information was registered using a modified World Health Organization oral health assessment form. This form includes the following clinical data:

- Dentition status: For each erupted tooth, the condition was recorded as (Decay, missing and filled teeth surfaces (DMFS/dmfs).
- Hard tissue status (Presence of erosion, attrition, recessions, staining).
- Periodontal and oral hygiene status (Presence of plaque, calculus, gingivitis, periodontitis).
- Soft tissue status (evaluation of the floor of the mouth, tongue, vestibule, palate).
- Occlusal status (molar relationship, canine relationship, midline, overbite, overjet).

- Radiographs were obtained if films are indicated and appropriate for the patient's routine dental care.

Following the comprehensive clinical examination, the CDHC, or the principal researcher captured intraoral videos using an intraoral camera of each patient following the protocol tested in phase 1. The intraoral videos were saved in MP4 format using the same identification number code for each participant. The patient´s clinical record, along with any radiographs taken in the face-to-face oral examination, was stored in a UAB secure encrypted computer for following tele-examination in a folder assigned to each patient.

Phase 3. Telediagnosis

After a one-month wash-out period, the five examiners observed the intraoral videos recorded from the same face-to-face comprehensive examination they previously performed and the periapical radiographs for tele-diagnosis. The examiners assessed the oral cavity using digital records only. Findings were also registered in the same modified WHO oral health assessment form used in the face-to-face comprehensive examination.

Phase 4. Comparative Analyses

Diagnostic outcomes tabulated in Excel (Microsoft® 365 MSO (Version 2301 Build 16.0.16026.20002) 64-bit) from the clinical comprehensive examination were compared to the outcomes obtained and summarized in Excel from the assessment of the digital records (tele-examination). Findings related to caries, soft tissue, hard tissues, and occlusion obtained by both methods were compared. The outcome of each in-situ exam was directly compared to the results of the assessment based on the digital records of the same patient. In this assessment, the clinical exam served as the gold standard and each examiner can be assumed to be calibrated against themselves.

Statistical Analysis

Intra-examiner agreement of the tele-examination using video camera records was determined using consistency (percent), and Cohen's Kappa coefficient (95% CI) (SAS 9.4 Cary, NC). Cohen's kappa (κ) is a measure of agreement between raters (interrater reliability) or between the evaluation of the same rater. This measure has five assumptions:

1) The responses (judgments) of raters are measured using a nominal scale (ordinal or nominal variable); categories are mutually exclusive.

2) Judgments are paired observations of the same phenomenon; raters (or the same rater twice) rate the same observations.

3) Each variable should have the same number of categories and the crosstabulation must be symmetrical (e.g., 2x2, 3x3, 4x4 crosstabulation, etc.).

4) The ratters (or the evaluations) are independent (one judgment does not affect the other one on the same phenomenon).

5) The same raters judge all the observations; raters are fixed or unique.

6) In this study, all the assumptions described were met.

Cohen's kappa is a statistical technique designed to determine the agreement of probabilities. It measures the proportion of agreements higher than the agreement expected at random (random agreement). The most common scale for interpreting agreement is the five-item scale proposed by Landis and Koch [106]: <0 no agreement;

0.00-0.20, slight agreement; 0.21-0.40, fair agreement; 0.41-0.60, moderate agreement; 0.61 - 0.80, substantial agreement; 0.81-1.00, almost perfect agreement. 95% confidence intervals (95% CI) are generally established.

CHAPTER 3

RESULTS

Description of the Sample

Table 1 shows demographics of the population included in this study along with the dental caries examination findings obtained from traditional oral clinical examination and digital oral examination one month later by the same examiner.

Table 1

Description of the sample

Variables	**Description**
Sample	50 children
Range of age	5 to y10 years
Number of teeth examined	1108 teeth
Number of surfaces examined	4990 surfaces
Primary teeth	639 teeth
Anterior primary teeth	308 teeth
Posterior primary teeth	331 teeth
Permanent anterior teeth	271 teeth
Permanent posterior teeth	198 teeth
Permanent teeth	469 teeth
Number of surfaces with dental caries from face-to face	426 surfaces
Number of surfaces with dental caries from telediagnosis	410 surfaces

Overall Agreement on the Assessment of Oral Conditions

Table 2 shows the overall intra-examiner agreement for diagnostic records from intraoral video and standard clinical comprehensive dental examinations in children performed by pediatric dental residents. The general results suggest that the proportion of agreement between the two judgments of the five examiners was almost perfect with a Kappa value of 0.85 (0.73-0.95) and a 98% of Consistency. Thus, it can be noted that pediatric dental residents were diagnosing children consistently using both procedures.

Table 2

Overall agreement on the Assessment of Oral Conditions

Variables	**Consistency***	**Kappa (95%CI) †**
Dental caries detection	98%	0.89 (0.82-0.94)
Assessment of hard tissues	98%	0.93 (0.82-1.00)
Assessment of oral hygiene	95%	0.82 (0.61-1.00)
Assessment of dental occlusion	83%	0.64 (0.40-0.88)
Overall agreement	93.5%	0.85 (0.73-0.95)

Notes: *Consistency is the percent agreement between traditional oral clinical examination versus digital oral examination one month later by the same examiner.

†Kappa and 95% Confidence Interval (CI) Using a five-item scale to assess agreement. ≤ 0 as indicating no agreement and 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41–0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement

Overall Agreement on the Screening for Dental Caries

Table 3 presents data that shows that the average agreement proportion between both evaluations for the detection of dental caries in primary teeth was almost perfect (κ =0.82). The agreement between evaluations for the detection of caries in primary posterior teeth was substantial (κ =0.79), and primary anterior teeth was almost perfect (κ =0.84).

Table 3

Overall Agreement on caries detection in primary teeth

Caries variables in primary teeth	**Consistency**	**Kappa (95%CI) †**
Caries detection in primary teeth	94%	0.82 (0.71-0.90)
Caries detection in primary posterior teeth	97%	0.79 (0.68-0.89)
Caries detection in primary anterior teeth	98%	0.84 (0.74-0.91)

Notes: †Kappa and 95% Confidence Interval (CI) Using a five-item scale to assess agreement. ≤ 0 as indicating no agreement and 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41– 0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement.

Agreement on the Detection of Dental Caries in Primary Teeth

Figure 1 shows the consistency representing the observed proportion of overall agreement (percentage in which both assessments agree) in primary posterior teeth. A high level of agreement, higher than 90% coincidence in both evaluations, was observed for the detection of dental caries (distal, facial, lingual, mesial, and occlusal). The lingual surface of tooth S showed the lowest percentage of agreement C= 90%. Universal tooth numbering used.

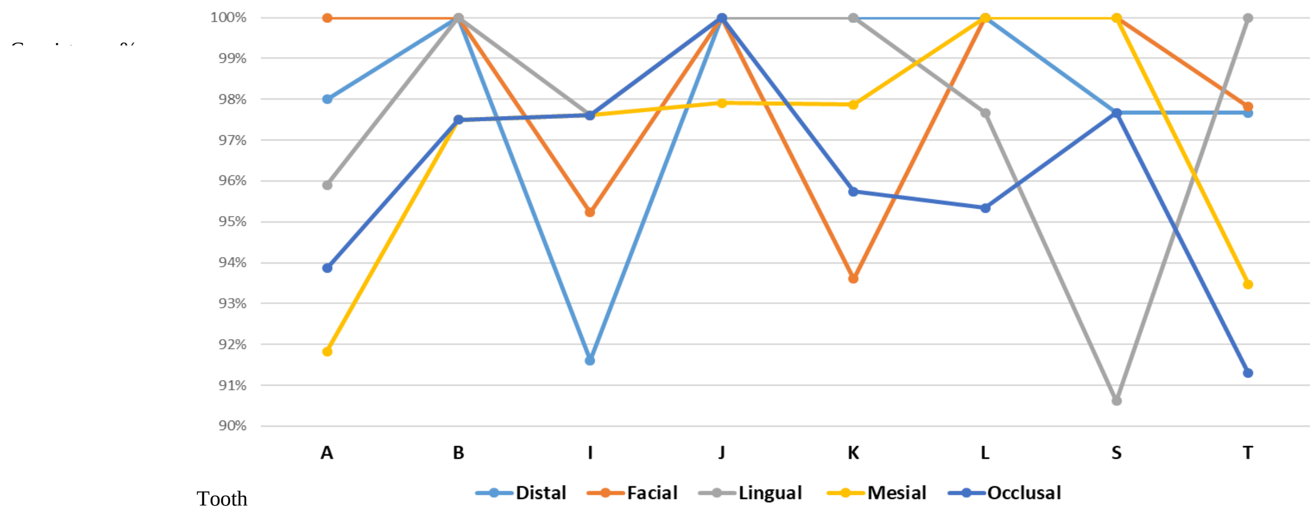

Figure 1. Agreement on the detection of dental caries in primary posterior teeth.

Note: Average evaluation between traditional oral clinical examination versus digital oral examination one month later by the same examiner. Letters are of universal tooth numbering for primary anterior teeth, percentage for consistency between both modalities, and different surfaces are represented by colors.

Table 4 indicates that the agreement in both assessments is almost perfect (κ between 0.81 and 1.0) for caries detection in the majority of primary posterior teeth examined. In the case of teeth A distal (κ =0.00) and I facial (κ = -0.02), no agreement

between both assessments was found. On the other hand, for the teeth A lingual (κ =0.47) and S lingual (κ =0.30), a fair to moderate agreement was observed. In contrast, for I lingual (κ =0.65), A mesial (κ =0.78), K facial (κ =0.63), and T facial (κ =0.78), a substantial agreement between thsoe assessments was reported. Finally, for A occlusal (κ

=0.85), an almost perfect agreement was found. In addition, for all cases that reported agreement, results are considered statistically significant with 95% CI.

Table 4

Agreement on caries detection in primary posterior teeth

Universal Tooth Numbering	**Distal** **Kappa (95%CI)†**	**Buccal** **Kappa (95%CI)†**	**Lingual** **Kappa (95%CI)†**	**Mesial** **Kappa (95%CI)†**	**Occlusal** **Kappa (95%CI)†**
A	0.00 (0,00-0.00)	1.00 (1.00-1.00)	0.47 (0.13-1.00)	0.70 (0.42-0.97)	0.85(0.69, 1.00)
B	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	0.84 (0.54-1.00)	0.90 (0.73-1.00)
I	0.89 (0.69-1.00)	-0.02 (-0.06-0.01)	0.65 (0.22-1.00)	0.78 (0.38-1.00)	0.84 (0.54-1.00)
J	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	0.93 (0.80-1.00)	1.00 (1.00-1.00)
K	1.00 (1.00-1.00)	0.63 (0.26-1.00)	1.00 (1.00-1.00)	0.93 (0.82-1.00)	0.90 (0.77-1.00)
L	1.00 (1.00-1.00)	1.00 (1.00-1.00)	0.00 (0.00-0.00)	1.00 (1.00-1.00)	0.86 (0.69-1.00)
S	0.94 (0.84-1.00)	1.00 (1.00-1.00)	0.30 (0.15-0.77)	1.00 (1.00-1.00)	0.94 (0.82-1.00)
T	0.84 (0.55-1.00)	0.78 (0.54-1.00)	1.00 (1.00-1.00)	0.78 (0.54-1.00)	0.82 (0.65-0.98)

Notes: †Kappa and 95% Confidence Interval (CI) Using a five-item scale to assess agreement. ≤ 0 as indicating no agreement and 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41– 0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement.

Figure 2 shows consistency representing the observed total proportion of agreement (percentage in which both assessments agree). In percentage terms, a high level of consistency can be seen, with higher than 85% coincidences between both evaluations for primary anterior teeth (distal, facial, lingual, and mesial). The distal and lingual surface of tooth O showed the lowest percentage of consistency (C = 87%).

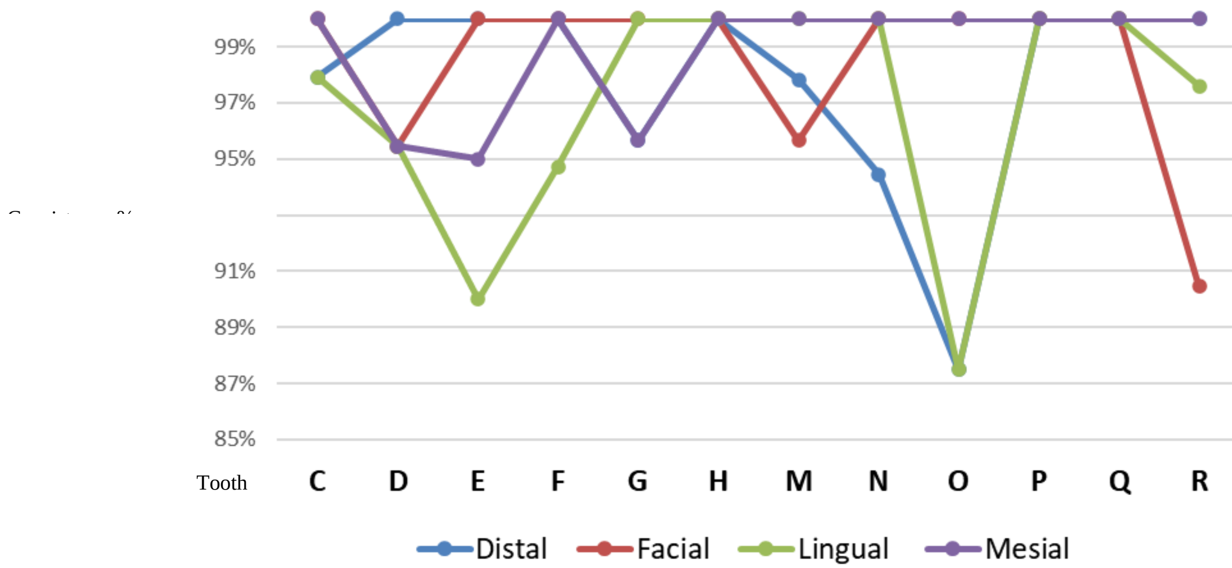

Figure 2. Agreement on caries detection in primary anterior teeth.

Notes: Average evaluation between traditional oral clinical examination versus digital oral examination one month later by the same examiner. Letters are universal tooth numbering for primary posterior teeth, percentage for consistency between both modalities, and different surfaces are represented by colors.

Table 5 indicates that the proportion of agreement is almost perfect in both evaluations (κ= 0.81-1.0) for the detection of caries in the majority of primary anterior teeth examined. For the case of G distal (κ =0.00), M distal (κ =0.00), N distal (κ =0.00), O lingual (κ =0.00), and R facial (κ =0.28), no agreement was observed. In contrast, for teeth D facial (κ =0.65), C lingual (κ =0.65), M facial (κ =0.72), E lingual (κ =0.76), and R lingual (κ =0.78), a substantial agreement was found between both evaluations. Similarly, for all cases that reported agreement, the results are considered statistically significant with 95% CI.

Table 5

Agreement on caries detection in primary anterior teeth

Universal Tooth Numbering	**Distal Kappa (95%CI) †**	**Facial Kappa (95%CI) †**	**Lingual Kappa (95%CI) †**	**Mesial Kappa (95%CI) †**
C	0.84 (0.55-1.00)	1.00 (1.00-1.00)	0.65 (0.03-100)	1.00 (1.00-1.00)
D	1.00 (1.00-1.00)	0.65 (0.03-1.00)	0.77 (0.35-1.00)	0.83 (0.51-1.00)
E	1.00 (1.00-1.00)	1.00 (1.00-1.00)	0.76 (0.45-1.00)	0.88 (0.67-1.00)
F	1.00 (1.00-1.00)	1.00 (1.00-1.00)	0.88 (0.66-1.00)	1.00 (1.00-1.00)
G	0.00 (0.00-0.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	0.86 (0.60-1.00)
H	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
M	0.00 (0.00-0.00)	0.72 (0.36-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
N	0.00 (0.00-0.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
O	0.61 (-0.07-1.00)	1.00 (1.00-1.00)	0.00 (0.00-0.00)	1.00 (1.00-1.00)
P	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
Q	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
R	1.00 (1.00-1.00)	0.28 (-0.22-0.79)	0.78 (0.38-1.00)	1.00 (1.00-1.00)

Notes: †Kappa and 95% Confidence Interval (CI) Using a five-item scale to assess agreement. ≤ 0 as indicating no agreement and 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41– 0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement

Agreement with Caries Detection in Permanent Teeth

Table 6 shows that the average proportion of agreement between both evaluations is almost perfect (κ =0.96) for the detection of caries in permanent teeth. This result is statistically significant (95% CI). Similar results were observed in the detection of caries in the permanent posterior teeth (κ =0.96) and permanent anterior teeth (κ =0.96).

Table 6

Agreement on caries detection in permanent teeth

Permanent teeth variables	Consistency*	Kappa (95%CI) †
Permanent posterior teeth	99.3%	0.96 (0.91-1.00)
Permanent anterior teeth	100%	0.96 (0.93-0.96)
Detection of caries in permanent teeth	99.6%	0.96 (0.93-0.98)

Notes: *Consistency is the percent agreement by tooth surface. †Kappa and 95% Confidence Interval (CI) Using a five-item scale to assess agreement.

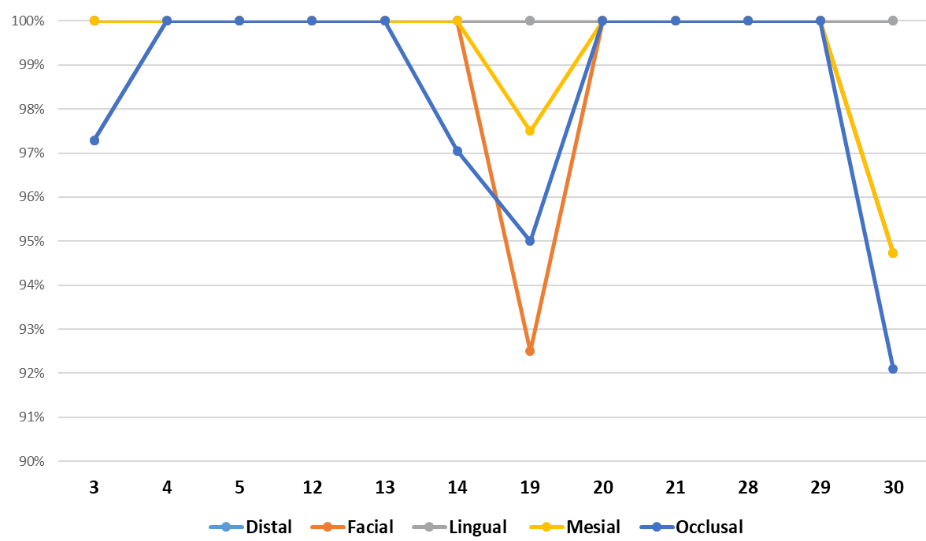

Figure 3. Agreement on caries detection in permanent posterior teeth.

Notes: Average evaluation between traditional oral clinical examination versus digital oral examination one month later by the same examiner. Numbers are universal tooth numbering for permanent posterior teeth, percentage for consistency between both modalities, and different surfaces are represented by colors.

Figure 3 shows the consistency of the observed overall proportion of agreement (both assessments agree). In percentage terms, a high level of consistency can be seen with a higher than 90% coincidence of both evaluations for the detection of caries in the permanent posterior teeth (distal, facial, lingual, mesial, and occlusal). The occlusal and facial aspects of teeth 19, 30 showed the lowest consistency C = 92%.

Table 7 shows the average proportion of agreement in the detection of caries in most permanent posterior teeth examined in both evaluations is almost perfect with a Kappa value between 0.83-1.0. In the 19 facial surface (κ=0.37), a fair agreement was observed, but this kappa value is not statistically significant since the IC includes zero value. In the case of tooth 30 facial (κ =0.65), 3 lingual (κ =0.65), 19 mesial (κ =0.65), and 30 mesial (κ =0.64), a substantial agreement was observed between both evaluations. However, despite the differences in the agreement, results are considered statistically significant (95% CI).

Table 7

Agreement on caries detection in permanent posterior teeth

Universal Tooth Numbering	**Distal** **Kappa (95%CI) †**	**Facial** **Kappa (95%CI) †**	**Lingual** **Kappa (95%CI) †**	**Mesial** **Kappa (95%CI) †**	**Occlusal** **Kappa (95%CI) †**
3	1.00 (1.00-1.00)	1.00 (1.00-1.00)	0.65 (0.02-1.00)	1.00 (1.00-1.00)	0.90 (0.72-1.00)
4	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
5	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
12	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
13	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
14	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	0.93 (0.79-1.00)
19	1.00 (1.00-1.00)	0.37(-0.15-0.90)	1.00 (1.00-1.00)	0.65 (0.02-1.00)	0.87 (0.75-1.00)
20	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
21	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
28	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
29	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
30	1.00 (1.00-1.00)	0.65 (0.32-1.00)	1.00 (1.00-1.00)	0.64 (0.19-1.00)	0.83 (0.65-1.00)

Notes: †Kappa and 95% Confidence Interval (CI) Using a five-item scale to assess agreement. ≤0 as indicating no agreement and 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41– 0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement

Figure 4 shows the consistency of the observed overall proportion of agreement (percentage in which both assessments agree). A high level of consistency was found (> 95% coincidence) between both evaluations for permanent anterior teeth (distal, facial, lingual, and mesial). The Lingual and Mesial aspects of tooth 8 showed the lowest percentage of agreement C= 96%.

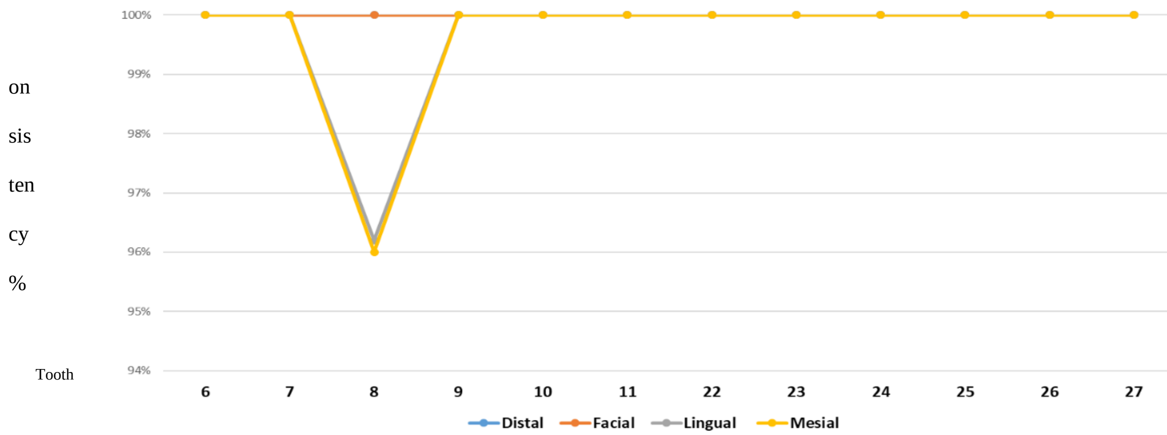

Figure 4. Agreement on caries detection permanent anterior teeth.

Notes: Average evaluation between traditional oral clinical examination versus digital oral examination one month later by the same examiner. Numbers for universal tooth numbering for permanent anterior teeth, percentage for consistency between both modalities, and different surfaces are represented by colors.

Table 8 indicates that the agreement ratio for caries detection in permanent anterior teeth examined in both assessments is almost perfect (κ=1.0). For 8 lingual (k=0.00) and 8 mesial (κ =0.00), no agreement was reported. For the remaining permanent anterior teeth, an almost perfect agreement was found.

Table 8

Agreement on caries detection in permanent anterior teeth

Universal Tooth Numbering	**Distal** **Kappa (95%CI) †**	**Facial** **Kappa (95%CI) †**	**Lingual** **Kappa (95%CI) †**	**Mesial** **Kappa (95%CI) †**
6	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
7	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
8	1.00 (1.00-1.00)	1.00 (1.00-1.00)	0.00 (0.00-0.00)	0.00 (0.00-0.00)
9	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
10	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
11	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
22	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
23	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
24	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
25	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
26	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
27	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)

Notes: †Kappa and 95% Confidence Interval (CI) Using a five-item scale to assess agreement. ≤ 0 as indicating no agreement and 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41– 0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement.

Agreement on the Hard Tissues Assessment

Table 9 shows that the proportion of agreement on the evaluation of hard tissues between both evaluations is almost perfect (κ =0.93). This result is statistically significant (95% CI). Similar findings were observed considering enamel defects (κ =1.00), erosion (κ =0.82), attrition (κ =0.92), and staining (κ =0.96).

Table 9

Agreement on the hard tissues assessment

Hard tissues assessment	**Consistency**	**Kappa (95%CI) †**
Enamel defects	100%	1.00 (1.00-1.00)
Erosion	94%	0.82 (0.62-1.00)
Attrition	98%	0.92 (0.77-1.00)
Staining	98%	0.96 (0.88-1.00)
Overall hard tissues assessment	98%	0.93 (0.82-1.00)

Notes: †Kappa and 95% Confidence Interval (CI) Using a five-item scale to assess agreement. ≤ 0 as indicating no agreement and 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41– 0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement.

Agreement on the Assessment of Oral Hygiene

Table 10 indicates that the proportion of agreement on the assessment of oral hygiene between both evaluations is almost perfect (κ =0.82). These results are statistically significant (95% CI). Similarly, the agreement between both evaluations is almost perfect when considering soft tissue (κ =1.00), calculus (κ =0.83), and gingivitis (κ =0.80). Agreement for plaque (κ =0.65) reported was substantial between both assessments.

Table 10

Agreement on the assessment of soft tissue and oral hygiene

Assessment of soft tissue/oral hygiene	**Consistency**	**Kappa (95%CI) †**
Soft tissue	100%	1.00 (1.00-1.00)
Plaque	94%	0.65 (0.23-1.00)
Calculus	94%	0.83 (0.63-1.00)
Gingivitis	92%	0.80 (0.59-1.00)
Overall assessment of oral hygiene	95%	0.82 (0.61-1.00)

Notes: †Kappa and 95% Confidence Interval (CI) Using a five-item scale to assess agreement. ≤ 0 as indicating no agreement and 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41– 0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement.

Agreement on the Evaluation of the Dental Occlusion

Table 11 shows that the proportion of agreement for the evaluation of dental occlusion between both evaluations is substantial (κ =0.64). This result is statistically significant (95% CI). Similar findings were observed between both evaluations considering molar occlusion (κ =0.73), canine occlusion (κ =0.73), and overbite (κ =0.68). in contrast, overjet (κ =0.49) and normal midline (κ =0.56) reported moderate agreement between both evaluations.

Table 11

Agreement on the evaluation of the dental occlusion

Occlusal assessment	**Consistency**	**Kappa (95%CI)** †
Molar occlusion	84%	0.73 (0.53-0.93)
Canine occlusion	87%	0.73 (0.51-0.96)
Midline Normal	78%	0.56 (0.33-0.79)
Overbite	84%	0.68 (0.46-0.90)
Overjet	84%	0.49 (0.17-0.82)
Overall occlusal assessment	83%	0.64 (0.40-0.88)

Notes: †Kappa and 95% Confidence Interval (CI) Using a five-item scale to assess agreement. ≤ 0 as indicating no agreement and 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41– 0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement.

CHAPTER 4

DISCUSSION

Control and prevention of oral diseases are associated with the accessibility of oral health care [28]. If attention to oral health is addressed when providing primary health care, it is possible to reduce risk factors and, therefore, the prevalence of oral diseases [28]. Nevertheless, optimal accessible primary oral health services are scarce for distant, isolated [24,26–28 29–32], critical, and socially undeserved communities [31,32,50,58,59], due to limited resources or inaccessibility to provide them the appropriate oral health care [28].

As an attempt to improve oral health care [28], the current study points toward the use of telediagnosis as a valid alternative to the traditional face-to-face oral assessment.

The development of teledentistry has permitted remote diagnoses in all dental specialties through examinations of digital images [57,105]. Teledentistry has also allowed sharing of radiographic images, which increases the rate of a correct and accurate diagnosis [105]. In addition, intraoral video cameras are considered affordable resources that can produce good quality and easily shareable videos in a secure and safe manner to protect patient identification.

Within the practice of teledentistry, the use of digital images for oral diagnosis is also important for the registration, control, and treatment of patients, particularly in cases of insurance compensations, legal actions, and retrospective investigations [54,105]. It has been proposed that intraoral photographs are effective for the diagnosis of oral diseases [107]. Furthermore, the current study suggests that intraoral video records can also be useful for oral comprehensive examinations.

This research project aimed to assess the intra-examiner agreement of the diagnostic outcomes of a telediagnosis from the comprehensive oral examination using intraoral video records compared to the diagnostic outcomes of a clinical comprehensive examination conducted by pediatric dental residents. Kappa results should be interpreted as follows [75]: values ≤ 0 as indicating no agreement, 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41–0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement.

These findings demonstrated a moderate to almost perfect intra-examiner agreement between the diagnosis from clinical face-to-face visual examination and that obtained from intraoral video records for oral health assessment. The Kappa results range from 0.64 to 0.94 for an oral evaluation. It indicates that for about 80% of the children examined in vivo, the diagnosis made with unaided visual examination was similar to the diagnosis made with intraoral video records. It was observed substantial and almost perfect agreements for assessing soft and hard tissues. In these cases, the agreement levels tended to be higher because these surfaces are easier to observe when they present problems as there are usually several teeth involved. These findings may suggest good reproducibility of both methods for the oral assessment.

Although it is known that different examiners could reach different diagnostic outcomes [108], coincidentally with Bissessur and Naidoo [109], examiners in this study had similar academic backgrounds, training, and clinical experience, and they were competent to screen for oral diseases; this fact could have a positive impact on the high concordance levels observed.

As reported in previous studies, the high level of agreement between visual tactile face-to-face examination and store-and-forward video assessment could indicate that this telediagnosis tool can be used for clinical purposes in distant, isolated, rural [24,26–28], underserved [29–32], critical, and socially disadvantaged communities [31,32,50,58,59].

In this research, data obtained on oral diseases through remote diagnosis were similar to those obtained by traditional face-to-face visual examination. In this study, Kappa results (0.83; 0.68-0.97) were similar to some previous studies. For example, Kopycka and Billings [35] reported 93% and 87% of intrarater agreement scores, Purohit [28] 87% and 82% obtained for clinical face-to-face and teledentistry assessment, Elfrink [110] from 89% to 100%, and Almeida et al. [111] from substantial to almost perfect agreement. These high kappa scores could suggest good reliability for both techniques. Perdoncini et al. [98] compared diagnostic outcomes from remote and face-to-face consultations. They observed an almost perfect agreement (k = 0.922).

Correspondingly, but in the elderly population, Mariño et al. [112] evaluated the viability of the use of teledentistry for teleconsultation and telediagnosis in residential aged care facilities. The Kappa intrarater agreement for dental examination parameters indicated an 'Excellent' agreement (Kappa=0.83), which suggests that the proposed teledentistry model could be an alternative to a traditional oral health examination.

Similarly, Queyroux et al. [113] found that an intraoral video-based teledentistry model had excellent sensitivity and specificity for diagnosing oral pathologies.

These finding can be especially useful in telehealth professional practice through the use of relatively low-cost equipment, such as digital intraoral video cameras and a personal computer with or without Internet access [57].

Regarding dental caries diagnosis, the intra-observer agreement between the diagnostic outcomes from clinical face-to-face visual examination and that obtained from intraoral video records for caries detection was almost perfect, as indicated by kappa values (κ =0.94; 0.88-0.99). Forgie et al. [114] found that the use of intraoral video cameras compared to the traditional visual examination is effective for the detection of occlusal caries. Similarly, Inquimbert et al. [115] observed that an intraoral video-based teledentistry consultation has an acceptable diagnostic outcome for dental caries detection and found that the Soprocare camera is efficient in the diagnosis of early caries. Equally, Purohit et al. [28] found that intraoral video-based teledentistry models are comparable to clinical examination when screening for dental caries among school children. Perdoncini et al. [98] also observed that a video-based synchronous teleconsultation obtained by a smartphone can offer a reliable remote diagnosis of oral lesions.

Some previous studies have assessed the use of smartphone-based teledentistry. Estai et al. [108] also observed an almost perfect intra-rater agreement between smartphone-based teledentistry and the standard dental screening methods for caries detection (K= 0.84). Likewise, Kohara et al. [65] observed that smartphone images and direct clinical examination have similar feasibility and accuracy for the diagnosis of caries. Karthikayan et al. [116]. Fonseca et al. [79] found that the use of smartphone cameras provides a valid and reliable method to screen for remote diagnosis of oral lesions. Maspero et al. [101] described the smartphone application Dental Monitoring ™ to offer an accurate clinical record of the patient's occlusion using a phone camera.

Similarly, agreement has been found between the diagnostic outcomes from clinical face-to-face visual examination and that obtained from intraoral images for caries detection. Steinmeier et al. [104] observed an agreement for dental caries ranging between 78% and 95%. Estai et al. [117] also found an almost perfect intra-rater agreement (0.82), which may suggest that examiners were consistent in detecting caries from photographs and visual clinical examination. Also, Pentapati et al. [75] found substantial to almost perfect agreement between the diagnostic outcomes from an intraoral video camera record and the conventional clinical examination for the diagnosis of dental caries in children. Likewise, other studies [57,71] on the use of intraoral photographs to screen for dental caries compared to the standard visual oral examination found that diagnosis based on intraoral images is a valid and reliable support to screen for dental caries. Similarly, Zafersoy-Akarslan et al. [118] and Almeida et al. [111] found Kappa statistics ranged from substantial to almost perfect for caries detection using both diagnostic methods.

In addition, Bissessur and Naidoo [109] found an almost perfect agreement between teledentistry and traditional dental screening methods for caries detection ranging from 95.09% to 98.30%.

Moreover, Kopycka and Billings [35] conducted a follow-up study using teledentistry examination for early childhood caries among preschool children in the US. They found that teledentistry is comparable to clinical examinations when screening to diagnose dental caries. Kohara et al. [65] also found that caries assessment performed on images provided by cameras is viable and similar to that accomplished clinically and accurately in caries detection. Boye et al. [119] found that the photographic assessment method is comparable to the visual examination method in primary dentition too.

Similarly, Estai et al. [74] found the intra-rater reliability for the photographic assessment was almost perfect with a kappa score of 0.89. However, the inter-rater reliability between the photographic and visual oral assessments was lower, ranging from moderate to substantial agreement, with kappa scores from 0.57 to 0.61.

In contrast, a recent study by Mazur et al. [120] compared the diagnostic outcomes of caries detection using visual examination with an intraoral camera in occlusal surfaces of first and second molar teeth. Results indicated that significant differences existed when comparing the two procedures.

Unlike the findings in this study, Purohit et al. [28] observed a fair degree of agreement between the visual tactile examination and the video-graphic method to screen for dental caries among 12-year-old school children in India.

These findings also disagreed with Castro Morosini et al. [57] and Kopycka et al. [71]. They observed much variation in kappa values, which may be associated with the difficulty of diagnosing caries from images they found due to the greater spectral sensitivity and illumination of the oral cavity by the intraoral camera [57,71]

Kopycka-Kedzierawski et al. [71] affirmed that, most likely, the disagreement on caries diagnosis between teledentistry images and the standard oral examination was attributable to the greater spectral sensitivity and illumination of the oral cavity by the intraoral camera, in that imaging of a child's mouth provides high-quality pictures for discrete evaluation [71]

Contrarily, Zafersoy-Akarslan et al. [118] found that around 40% of patients examined *in vivo* with unaided visual examination for caries detection differed from the diagnosis made with teledentistry. The greatest discrepancy occurred for surfaces that were diagnosed as sound or as having enamel lesions without cavitation using the unaided visual examination. But more of these surfaces were scored as caries when screening with visual technological aid.

In this study, agreement on the evaluation of soft tissue and oral hygiene between both techniques was almost perfect (κ =0.82). The assessment of oral hygiene includes soft tissue status (κ =1.00), calculus assessment (κ =0.83), and gingivitis (κ =0.80). However, plaque detection (κ =0.65) reported substantial agreement between both assessments. Likewise, Pentapati et al. [75] found substantial to almost perfect agreement between the intraoral video camera and clinical examination for the diagnosis of various oral conditions, such as calculus, plaque, and tooth wear in children.

Similarly, Giraudeau [121] and Mariño, et al. [112] compared the conventional clinical oral examinations to the teledentistry models as a diagnostic video-images-based tool for assessing oral hygiene, the presence of calculus, dental caries, periodontal status, and oral mucosa health. They found this teledentistry system is feasible, reliable, and valid as an alternative to the standard face-to-face oral examination and improves oral healthcare access to functionally dependent patients.

Fricton and Chen [31] state that teledentistry enhances regular dentist-patient communication, support, and supervision and facilitates teleconsultations to diagnose periodontal diseases by transmitting periodontal images [122]. In this regard, Jha et al. [123] propose a web-based dental healthcare application for preventing and treating periodontal diseases. Ojima et al. [124] developed and assessed a web-based intervention system to improve periodontal health, which included video images of toothbrush manipulation based on dental professional instructions. Improvements in the plaque index and periodontal status were observed over three months. Similarly, Smith et al. [125] found that the use of a digital camera with an image analysis system is a reliable and accurate method to measure dental plaque surface area.

Contrarily, Steinmeier et al. [104] found a moderate to low (fair) agreement between remote telediagnosis and visual clinical diagnosis for periodontal assessment. According to these authors, remote telediagnosis is not as accurate as visual clinical observation for a periodontal evaluation.

In this study, we observed an almost perfect (κ =0.93) agreement between both diagnostic techniques on the evaluation of hard tissues, regarding enamel defects (κ =1.00), erosion (κ =0.82), attrition (κ =0.92), and staining (κ =0.96). Congruently, Steinmeier et al. [104] found a moderate agreement between remote telediagnosis and visual clinical diagnosis for dental assessments concerning tooth erosion, tooth wear, and stains, ranging from 78% to 95%. Also, Pentapati et al. [75] found substantial to almost perfect agreement between the intraoral video camera and clinical examination for the diagnosis of fluorosis and dental staining in children. Likewise, Martins et al. [126] observed good (substantial) agreement on the diagnosis of enamel defects between intraoral images and direct clinical examination with a kappa value of 0.67. Al-Malik et al. [127] found that intraoral photographs have the potential for detecting and measuring dental erosion and Kopycka-Kedzierawski and Billing [60] observed that teledentistry screening can enhance the detection and measurement of dental attrition.

However, some other studies [66,121,128] found that images provided by a diagnostic video-images-based tool cannot distinguish between dental attrition, staining, and carious lesions. Moreover, Kohara et al. [65] found discrepancies between the detection of enamel lesions made clinically and that made based on intraoral images. Similarly, Chen et al. [129] observed a fair to moderate agreement between clinical and photographic methods for detecting defects of enamel in anterior primary teeth with Kappa values ranging from 0.252 to 0.514.

Otherwise, Chen et al. [129], Golkari et al. [130], and Cruz-Orcutt et al. [131] found that the use of intraoral images detected significantly more enamel defects than the direct clinical observation.

These results indicate that the agreement between both diagnostic techniques on the assessment of occlusion is substantial (κ =0.64), which includes molar occlusion (κ =0.73), canine occlusion (κ =0.73), and overbite (κ =0.68). Overjet (κ =0.49) and normal midline (κ =0.56) reported moderate, instead. The greatest discrepancy was found for overjet (0.49) and midline (0.56). In contrast, the greatest agreements occurred for attrition 0.92, staining 0.96, soft tissue 1.00, and enamel defects 1.00.

The low agreement and the high variability are probably due to some features related to occlusion that should be based on static images [132]. It seems to be more difficult to diagnose and evaluate occlusion based on intraoral videos. In this regard, intraoral photographs, using an intraoral camera [132–134], seem to be more appropriate, as found in previous studies [65,89,132,134].

Amável et al. [13] assessed the presence of calculus, gingivitis, dental fractures, and malocclusions remotely in preschool children Their results indicated sensitivity between

94% and 100% and specificity between 52% and 100%. The positive predictive value was between 67% and 100%; the negative predictive value was between 94% and 100%. They concluded that remote diagnosis of malocclusions based on photographs constitutes a valid resource to exclude referred children to a dentist for treatment [13].

Overall findings found in this study coincided with various previous studies. Berndt et al. [95] demonstrated that synchronic videoconferencing can be used in orthodontic treatments for malocclusions, as this teledentistry method can produce comparable results to those obtained by orthodontic specialists in the clinical face-to-face consultation, with a high compliance rate. McLaren and Kopycka [51] also found that a live-video teleconsultation is a feasible option for improving oral health access. Similarly, Pereira Da Costa et al. [77] suggest the use of teleconferencing for the diagnosis of oral lesions.

Finally, in general, these findings are in line with the majority of previous studies carried out in several countries, which have also found that teledentistry is an effective and economical tool to provide basic oral health care in rural and remote areas [18,28]. Besides, our findings also coincide with previous studies that have analyzed the use of teledentistry in different clinical dental practices, naming endodontics [135], screening for caries, dental emergencies, oral and maxillofacial surgery, oral medicine and pathology [136,137], orthodontics [89], and implantology [69]. Our results support the idea that the diagnostic outcomes of teledentistry, teleconsultation, and telediagnosis, seem to be as reliable as those obtained by using traditional face-to-face methods [18,57].

The findings of the current study should be interpreted with caution. Despite the almost perfect agreement of the diagnostic outcomes of the face-to-face clinical examination and the store-and-forward intraoral video method, the study had some limitations that could have affected our results. Unlike in the current research, previous studies on teledentistry (teleconsultation and telediagnosis in general dentistry and dental specialties) have usually analyzed intra- and interrater agreement, sensitivity, specificity, and positive and negative predictive values to calculate inter and intra-examiner reliability. Usually, those studies employed the decayed, missing, and filled teeth (DMFT) index. Their results may provide solid evidence on the accuracy, reliability, and effectiveness of teledentistry as an alternative screening tool for the assessment of oral diseases to recommend its use.

The small sample size could be considered another limitation of the current study; it was made of 50 patients, which is smaller than the majority of the samples included in previous studies.

Moreover, in this study, only intrarater agreement was analyzed. This could have limited the scope of the findings. However, the data collected could serve for inter-rater comparisons and ultimately these videos could be used for teaching undergraduate/graduate's dental students.

Another limitation of the current study is that it did not include a gold standard for determining whether the diagnosis was or was not correct; therefore, the true diagnosis for each patient was unknown.

Nonetheless, as a practical outcome, essentially zero patients with decay at the traditional examination were identified as caries free at the teledentistry examination. Although, more granularity of examination results consistency is desired, the main concern would have adequate sensitivity of caries diagnosis using teledentistry. This study did result in findings that support the achievement of that objective.

CHAPTER 5

CONCLUSION

In the current study, we compared the intraoral video diagnostic outcomes with those of the traditional visual approach of oral assessment. On the basis of our findings, we conclude:

1) Within the limitations of the present study, overall results indicate almost perfect intra-examiner agreement between the diagnosis from clinical face-to-face visual examination and that conducted from intraoral video records.
2) These findings suggest that the store-and-forward telediagnosis model is comparable to the standard clinical examination for the evaluation of oral hygiene, hard tissues, occlusion, and dental caries among school children.
3) This study suggests that the use of intraoral video records, captured by an intraoral camera, offers a valid means for remote oral assessment. This telediagnosis approach may be a potentially cost-effective alternative to address the problems related to remote oral care access and the rising costs of dental care.
4) Based on these findings, teledentistry may change the dynamics of dental care access to effectively bridge the gap between rural, poor, and urban oral health services.

Based on the results of this study, the following recommendations are proposed:

a) Further research should evaluate the accuracy and reliability and validity of the use of intraoral video records in comparison with the gold standard before this technique can be widely adopted for clinical diagnosis and assessment.

b) Further research is needed to assess the diagnostic accuracy, sensitivity, and specificity of intraoral video records captured by different intraoral video cameras.

c) Further research is needed to assess the inter-examiner comparison to evaluate the use of intraoral cameras as a tool for the comprehensive clinic and remote examination in children.

REFERENCES

1. Almazrooa SA, Mansour GA, Alhamed SA, Ali SA, Akeel SK, Alhindi NA, et al. The application of teledentistry for Saudi patients' care: A national survey study. J Dent Sci. 2021;16(1):280–6.

2. de Araújo Novaes M. Telecare within different specialties. In: Fundamentals of Telemedicine and Telehealth. Elsevier; 2019. p. 185–91.

3. Craig J, Patterson V. Introduction to the practice of telemedicine. J Telemed Telecare. 2016;11:3–9.

4. Mariño R, Ghanim A. Definition of Teledentistry. In: Giraudeau N, editor. e-Health Care in Dentistry and Oral Medicine: A clinician's guide. Springer; 2018. p. 3–14.

5. Brito B. Telemedicina no Brasil: Uma estratégia possível para o cuidado em saúde em tempo de pandemia? Rev Saúde em Redes. 2020;6(2):7–19.

6. Parrasi E, Celis L, Bocanegra J, Pascuas Y. Estado actual de la telemedicina: una revisión de literatura. Ingeniare. 2016;20:105–20.

7. Daniel SJ, Kumar S. Teledentistry: A key component in access to care. J Evid Based Dent Pract. 2014;14(SUPPL.):201–8.

8. Bo C, Peralta S, Lu A. How Has Teledentistry Been Applied in Public Dental Health Services? An Integrative Review. Telemed e-Health. 2019;26(7):945–54.

9. Macapagal J. Applications of Teledentistry during the COVID-19 Pandemic Outbreak. Appl Med Informatics. 2020;42(3):133–41.

10. Mariño R, Ghanim A. Teledentistry: A systematic review of the literature. J Telemed Telecare. 2013;19(4):179–83.

11. Chen JW, Hob-Dell MH, Dunn K, Johnson KA, Zhang J. Teledentistry and its use in dental education. J Am Dent Assoc. 2003;134(3):342–6.

12. Estai M, Kanagasingam Y, Mehdizadeh M, Vignarajan J, Norman R, Huang B, et al. Teledentistry as a novel pathway to improve dental health in school children: A research protocol for a randomised controlled trial. BMC Oral Health. 2020;20(1):1–9.

13. Amável R, Cruz-Correia R, Frias-Bulhosa J. Remote diagnosis of children dental problems based on non-invasive photographs - A valid proceeding? Stud Health Technol Inform. 2009;150:458–62.

14. McLaren SW, Kopycka-Kedzierawski DT, Nordfelt J. Accuracy of teledentistry examinations at predicting actual treatment modality in a pediatric dentistry clinic. J Telemed Telecare. 2017;23(8):710–5.

15. Langelier M, Rodat C, Moore J. Case studies of 6 teledentistry programs: strategies to increase access to general and specialty dental services. 2016.

16. Arizona Department of Health Services. Teledentistry in Arizona. Initial development. 2009.

17. Ghai S. Teledentistry during COVID-19 pandemic. Diabetes Metab Syndr Clin Res Rev. 2020;14(5):933–5.

18. Estai M, Kanagasingam Y, Tennant M, Bunt S. A systematic review of the research evidence for the benefits of teledentistry. J Telemed Telecare. 2018;24(3):147–56.

19. McLaren SW; Kopycka-Kedzierawski DT. Compliance with dental treatment recommendations by rural paediatric patients after a live-video teledentistry consultation: a preliminary report. Telemed Telecare. 2016;3:198–202.

20. Kopycka-Kedzierawski D, McLaren S, Billings R. Advancement of teledentistry at the University of Rochester's Eastman Institute for Oral Health. Health Aff. 2018;37(12):1960–6.

21. Boringi M, Waghray S, Lavanya R, Babu DBG, Badam RK, Harsha N, et al. Knowledge and awareness of teledentistry among dental professionals – a cross sectional study. J Clin Diagnostic Res. 2015;9(8):ZC41–4.

22. Baker WP, Loushine RJ, West LA, Kudryk L V, Zadinsky JR. Interpretation of Artificial and In Vivo Periapical Bone Lesions Comparing Conventional Viewing Versus a Video Conferencing System. J Endod. 2000;26(1):39–41.

23. Ologeanu-Taddei R, Bourdon I, Kimble C, Giraudeau N. Oral Healthcare and

Technologies : Breakthroughs in Research and Practice. IGI Global.; 2017.

24. Sengupta M, Mishra R, Bohidar S. Teledentistry-Past , present and future. J Odisha Dent Assoc. 2020;5(2):10–7.

25. Torres-Pereira CC, Almeida Castro Morosini I de, Fonseca BB. Teledentistry and the Distant Diagnosis of Oral Mucosal Disease. In: Kumar S, editor. Teledentistry. Springer; 2015. p. 13–21.

26. Inês Meurer M, Caffery LJ, Bradford NK, Smith AC. Accuracy of dental images for the diagnosis of dental caries and enamel defects in children and adolescents: A systematic review. J Telemed Telecare. 2015;21(8):449–58.

27. Daniel S, Kumar S. Access to oral care through teledentistry. In: Kuman S, editor. Teledentistry. Springer; 2015. p. 1–117.

28. Purohit BM, Singh A, Dwivedi A. Utilization of teledentistry as a tool to screen for dental caries among 12-year-old school children in a rural region of India. J Public Health Dent. 2017;77(2):174–80.

29. Arora PC, Kaur J, Kaur J, Arora A. Teledentistry: An innovative tool for the underserved population. Digit Med. 2019;5(1):6–12.

30. Kashani-Legler R. Minnesota Collaborative Agreement: Potential for Dental Hygienists to Increase Direct Access for Underserved Populations. ProQuest Diss Theses. 2016;149.

31. Fricton J, Chen H. Using teledentistry to improve access to dental care for the underserved. Dent Clin North Am. 2009;53(3):537–48.

32. Martin AB, Nelson JD, Bhavsar GP, McElligott J, Garr D, Leite RS. Feasibility assessment for using telehealth technology to improve access to dental care for rural and underserved populations. J Evid Based Dent Pract. 2016;16(4):228–35.

33. Thiel M. Connecting Physicians to Dentists via Teledentistry: Assessing Feasibility, Acceptability and Sustainability in a Children’s Hospital System. The Ohio State University; 2019.

34. Daniel S, Kumar S. Comparison of dental hygienists and dentists: Clinical and teledentistry identification of dental caries in children. Int J Dent Hyg. 2016;15(4):e143–8.

35. Kopycka-Kedzierawski DT, Billings RJ. Comparative effectiveness study to assess

two examination modalities used to detect dental caries in preschool urban children. Telemed e-Health. 2013 Nov 1;19(11):834–40.

36. Kopycka-Kedzierawski DT, Billings RJ. Teledentistry in inner-city child-care centres. J Telemed Telecare. 2006;12(4):176–81.

37. Nutalapati R, Boyapati R, Jampani NN, Dontula BSK, Nutalapati R, Dontula BSK, et al. Applications of teledentistry: A literature review and update. J Int Soc Prev Community Dent. 2011;2(2):37–44.

38. Daniel S, Farrow L. 10. Teledentistry in the United States. In: Giraudeau N, editor. e-Health Care in Dentistry and Oral Medicine: A clinician's guide. Springer; 2018. p. 125–30.

39. Telles-Araujo G de T, Caminha RDG, Kallás MS, Santos PS da S. Teledentistry support in covid-19 oral care. Clinics. 2020;75:1–2.

40. Giudice A, Barone S, Muraca D, Averta F, Diodati F, Antonelli A, et al. Can teledentistry improve the monitoring of patients during the Covid-19 dissemination? A descriptive pilot study. Int J Environ Res Public Health. 2020;17(10):1–9.

41. Mandall NA, Quereshi U, Harvey L. Teledentistry for screening new patient orthodontic referrals. Part 2: GDP perception of the referral system. Br Dent J. 2005 Dec 10;199(11):727–9.

42. Gillani M, Ullah A, Niaz HA, Graydon PJ, Butler RW, Finelli GB, et al. Teledentistry Overview: United States of America. J Int Soc Telemed Ehealth. 2019;7:e9.

43. Chang SW, Plotkin DR, Mulligan R, Polido JC, Mah JK, Meara JG. Teledentistry in rural California: a USC initiative. J Calif Dent Assoc. 2003;31(8):601–8.

44. Simon L, Friedland B. Interstate practice of dental teleradiology in the United States: The effect of licensing requirements on oral and maxillofacial radiologists' practice patterns. Telemed e-Health. 2016;22(6):541–5.

45. Dulieu LK. Preventative Dentistry Delivery to Children in Rural Communities in the United States. Dent Hypotheses. 2016;7(4):160–1.

46. Bhargava A, Sabbarwal B, Jaggi A, Chand S, Tandon S. Teledentistry: A literature review of evolution and ethicolegal aspects. J Glob Oral Heal. 2020;2(2):128–33.

47. Jain R, Puttaswamy B, Dupare R, Chitguppi R, Gaikwad R, Parekh N. Teledentistry: A Review and an Update. Indian J Oral Care Res. 2014;2(4):78–81.

48. Rocca MA, Kudryk VL, Pajak JC, Morris T. The evolution of a teledentistry system within the Department of Defense. Proc AMIA Symp. 1999;921–4.

49. Glassman P, Harrington M, Mertz E, Namakian M. The virtual dental home: implications for policy and strategy. J Calif Dent Assoc. 2012;40(7):605–11.

50. Summerfelt FF. Teledentistry-Assisted, Affiliated Practice for Dental Hygienists: An Innovative Oral Health Workforce Model. J Dent Educ. 2011;75(6):733–42.

51. McLaren SW, Kopycka-Kedzierawski DT. Compliance with dental treatment recommendations by rural paediatric patients after a live-video teledentistry consultation: A preliminary report. J Telemed Telecare. 2016;22(3):198–202.

52. Madrid Troconis C, Ribón JR, Puello P. Impact of Teledentistry Programs on Dental Service in Rural Areas: A Systematic Review. Int J Appl Eng Res. 2018;13(19):14417–23.

53. Schafer TE, Riggs B. Use of a Teledentistry Partnership Program to Reach a Rural Pediatric Population. J Georg Public Heal Assoc. 2017;6(3):390–2.

54. Skillman SM, Doescher MP, Mouradian WE, Brunson DK. The challenge to delivering oral health services in rural America. J Public Health Dent. 2010;70(SUPPL. 1):s49–57.

55. Teoh J, Hsueh A, Marinõ R, Manton D, Hallett K. Economic evaluation of teledentistry in cleft lip and palate patients. Telemed e-Health. 2018;24(6):449–56.

56. Mariño R, Manton D, Marwaha P, Hallett K, Clarke K, Hopcraft M, et al. The Implementation of Teledentistry for Pediatric Patients. In: GLOBAL HEALTH 2014: The Third International Conference on Global Health Challenges. 2014. p. 14–9.

57. Castro Morosini I, De Oliveira DC, Ferreira FDM, Fraiz FC, Torres-Pereira CC. Performance of distant diagnosis of dental caries by teledentistry in juvenile offenders. Telemed e-Health. 2014;20(6):584–9.

58. Cooper BR, Engeswick LM. Knowledge, attitudes, and confidence levels of dental hygiene students regarding teledentistry: a pilot study. J Dent Hyg. 2007;5(4):1–4.

59. Estai M, Bunt S, Kanagasingam Y, Tennant M. Cost savings from a teledentistry

model for school dental screening: An Australian health system perspective. Aust Heal Rev. 2018;42(5):482–90.

60. Kopycka-Kedzierawski DT, Billings RJ. Prevalence of dental caries and dental care utilisation in preschool urban children enrolled in a comparative-effectiveness study. Eur Arch Paediatr Dent. 2011;12(3):133–8.

61. American Teledentistry Association. Teledental practice and teledental encounters: an american association of teledentistry position paper. 2017.

62. Northridge ME, Littlejohn T, Mohadjeri-franck N, Gargano S, Troxel AB, Wu Y, et al. Feasibility and acceptability of an oral pathology asynchronous tele-mentoring intervention: A protocol. J Public health Res. 2020;9:1777.

63. Eisenchlas SA. Gendered discursive practices on-line. J Pragmat. 2012;44(4):335–45.

64. Estai M. Photographic Caries Assessment by Different Members of the Dental Team: A Mobile Teledentistry Model. University of Western Australia; 2017.

65. Kohara EK, Abdala CG, Novaes TF, Braga MM, Haddad AE, Mendes FM. Is it feasible to use smartphone images to perform telediagnosis of different stages of occlusal caries lesions? PLoS One. 2018;13(9):1–13.

66. Jablonski-Momeni A, Schipper HM, Rosen SM, Heinzel-Gutenbrunner M, Roggendorf MJ, Stoll R, et al. Performance of a fluorescence camera for detection of occlusal caries in vitro. Odontology. 2011;99(1):55–61.

67. Huerta-Guerrero C, López-Domínguez E, Hernández- Velázquez Y, Domínguez-Isidro S, Cueto-García A, De-La-Calleja J, et al. Kaanbal: A Mobile Learning Platform Focused on Monitoring and Customization of Learning. Int J Emerg Technol Learn. 2020;16(1):18–43.

68. Godlevsky L, Bidnyuk E, Bayazitov N, Kresyun N, Kovalenko A, Lyashenko A, et al. Application of mobile photography with smartphone cameras for monitoring of early caries appearance in the course of orthodontic correction with dental brackets. Appl Med Informatics. 2013;33(4):21–6.

69. Suetenkov DE, Popkova O V., Kiselev AR. Possibilities and limitations of teledentistry. Rev Cubana Estomatol. 2020;57(1):e2968.

70. Petruzzi M, De Benedittis M. WhatsApp: A telemedicine platform for facilitating remote oral medicine consultation and improving clinical examinations. Oral Surg

Oral Med Oral Pathol Oral Radiol. 2016;121(3):248–54.

71. Kopycka D, Billings R, McConnochie K. Dental screening of preschool children using teledentistry: A feasibility study. Pediatr Dent. 2007;29(3):209–13.

72. Namakian M, Subar P, Glassman P, Quade R, Harrington M. In-person versus “virtual” dental examination: congruence between decision-making modalities. J Calif Dent Assoc. 2012 Jul 1;40(7):587–95.

73. Subbalekshmi T, Anandan V, Apathsakayan R. Use of a Teledentistry-based Program for Screening of Early Childhood Caries in a School Setting. Cureus. 2017;9(7):1–7.

74. Estai M, Kanagasingam Y, Huang B, Checker H, Steele L, Kruger E, et al. The efficacy of remote screening for dental caries by mid-level dental providers using a mobile teledentistry model. Community Dent Oral Epidemiol. 2016;44(5):435–41.

75. Pentapati KC, Mishra P, Damania M, Narayanan S, Sachdeva G, Bhalla G. Reliability of intraoral camera using teledentistry in screening of oral diseases – Pilot study. Saudi Dent J. 2017;29(2):74–7.

76. Yeboah J, Ewur GD. The impact of Whatsapp messenger usage on students performance in tertiary institutions in Ghana. J Educ Pract. 2014;5(6):157–64.

77. Pereira Da Costa A, Lazaro SA, Molina-Bastos CG, Guattini V, Umpierre RN, Gonçalves M, et al. Teledentistry in the diagnosis of oral lesions: A systematic review of the literature. J Am Med Informatics Assoc. 2020;27(7):1166–72.

78. Aziz SR, Ziccardi VB. Telemedicine Using Smartphones for Oral and Maxillofacial Surgery Consultation, Communication, and Treatment Planning. J Oral Maxillofac Surg. 2009;67(11):2505–9.

79. Fonseca B, Amenábar J, Piazzetta C, Schussel J, Lemos-Júnior C, Torres-Pereira C. Diagnóstico à distância de lesões bucais com fotografias de smartphones. Rev la Asoc Cir Dent São Paulo. 2016;70(1):52–7.

80. Estai M, Kruger E, Tennant M. Optimizing patient referrals to dental consultants: Implication of teledentistry in rural settings. Australas Med J. 2016;9(7):249–52.

81. Tella A, Olanloye O, Ibiyemi O. Potential of Teledentistry in the Delivery of Oral Health Services in Developing Countries. Ann Ibadan Postgrad Med. 2019;17(2):115–23.

82. Poelman T. Nationwide survey of teledentistry regulations. 2020.

83. Irving M, Stewart R, Spallek H, Blinkhorn A. Using teledentistry in clinical practice, an enabler to improve access to oral health care: A qualitative systematic review. J Telemed Telecare. 2017;24(3):129–46.

84. Daniel S, Wu L, Kumar S. Teledentistry: A systematic review of clinical outcomes, utilization and costs. J Dent Hyg. 2013;87(6):345–52.

85. Estai M, Bunt S, Kanagasingam Y, Kruger E, Tennant M. Diagnostic accuracy of teledentistry in the detection of dental caries: a systematic review. J Evid Based Dent Pract. 2016 Sep 1;16(3):161–72.

86. Alabdullah JH, Daniel SJ. A Systematic Review on the Validity of Teledentistry. Telemed e-Health. 2018;24(8):639–48.

87. Mesa NF, Hoyos VH. Applications of teledentistry in dental practice: a systematic review. Rev Fac Odontol Univ Antioquia. 2020;32(1):77–88.

88. Patterson S, Botchway C. Dental screenings using telehealth technology: a pilot study. J Can Dent Assoc. 1998;64(11):806–10.

89. Mandall NA, O'brien KD, Brady J, Worthington H V, Harvey L. Teledentistry for screening new patient orthodontic referrals. Part 1: A randomised controlled trial. Br Dent J. 2005;199(10).

90. Stephens C, Cook J, Mullings C. Orthodontic referrals via TeleDent Southwest. Dent Clin North Am. 2002;46(3):507–20.

91. Jeong JS, Pang NS, Choi Y, Park KM, Kim T, Xu X, et al. Importance of photography education to improve image quality for accurate remote diagnoses in dental trauma patients: Observational study. JMIR mHealth uHealth. 2020;8(3):1–8.

92. Abdelrahim A, Shimpi N, Hegde H, Kleutsch KC, Chyou PH, Jain G, et al. Feasibility of establishing tele-dental approach to non-traumatic dental emergencies in medical settings. Am J Dent. 2020;33(1):48–52.

93. Brucoli M, Boffano P, Franchi S, Pezzana A, Baragiotta N, Benech A. The use of teleradiology for triaging of maxillofacial trauma. J Cranio-Maxillofacial Surg. 2019;47(10):1535–41.

94. Torres-Pereira C, Possebon RS, Simões A, Bortoluzzi MC, Leão JC, Giovanini

AF, et al. Email for distance diagnosis of oral diseases: A preliminary study of teledentistry. J Telemed Telecare. 2008;14(8):435–8.

95. Berndt J, Leone P, King G. Using teledentistry to provide interceptive orthodontic services to disadvantaged children. Am J Orthod Dentofac Orthop. 2008;134(5):700–6.

96. Cook J, Mullings C, Vowles R, Ireland R, Stephens C. Online orthodontic advice: A protocol for a pilot teledentistry system. J Telemed Telecare. 2001;7(6):324–33.

97. Brüllmann D, Schmidtmann I, Warzecha K, d'Hoedt B. Recognition of root canal orifices at a distance - a preliminary study of teledentistry. J Telemed Telecare. 2011;17(3):154–7.

98. Perdoncini NN, Schussel JL, Amenábar JM, Torres-Pereira CC. Use of smartphone video calls in the diagnosis of oral lesions: Teleconsultations between a specialist and patients assisted by a general dentist. J Am Dent Assoc. 2021;152(2):127–35.

99. Herce J, Lozano R, Salazar CI, Rollon A, Mayorga F, Gallana S. Management of impacted third molars based on telemedicine: A pilot study. J Oral Maxillofac Surg. 2011;69(2):471–5.

100. Ignatius E, Perãlãt S, Mãkelã K. Use of videoconferencing for consultation in dental prosthetics and oral rehabilitation. J Telemed Telecare. 2010;16(8):467–70.

101. Maspero C, Abate A, Cavagnetto D, El Morsi M, Fama A, Farronato M. Available Technologies, Applications and Benefits of Teleorthodontics. A Literature Review and Possible Applications during the COVID-19 Pandemic. J Clin Med. 2020;9(6):1891.

102. Mouthwatch. Teledentistry Quick Facts Guide What to know about teledentistry in your state. 2020.

103. Naughton DK. Expanding oral care opportunities: Direct access care provided by dental hygienists in the United States. J Evid Based Dent Pract. 2014;14(SUPPL.):171-182.e1.

104. Steinmeier S, Wiedemeier D, Hämmerle CHF, Mühlemann S. Accuracy of remote diagnoses using intraoral scans captured in approximate true color: A pilot and validation study in teledentistry. BMC Oral Health. 2020;20(1):1–15.

105. de Almeida R, Rezende L, Da-Silva C, Almeida JC. Remote diagnosis of traumatic

dental injuries using digital photographs captured via a mobile phone. Dent Traumatol. 2017;33(5):350–7.

106. Landis R, Koch G. The measurement of observer agreement for categorical data. Biometrics. 1977;33(1):159–74.

107. Kerins C a. Cooperation Predictors for Dental Patients with Autism. Pediatr Dent. 1999;29(5):369–76.

108. Estai M, Kanagasingam Y, Huang B, Shiikha J, Kruger E, Bunt S, et al. Comparison of a Smartphone-Based Photographic Method with Face-to-Face Caries Assessment: A Mobile Teledentistry Model. Telemed e-Health. 2017;23(5):435–40.

109. Bissessur S, Naidoo S. A comparative analysis of traditional dental screening versus teledentistry screening. South African Dent J. 2019;74(1):19–23.

110. Elfrink M. The Evaluation for Oral Examination by Using of Intraoral camera. Int J Clin Prev Dent. 2014;10(2):113–20.

111. Almeida I De, Morosini C, Ferreira FM. Performance of Distant Diagnosis of Dental Caries by Teledentistry in Juvenile Offenders. 2014;(April).

112. Mariño R, Hopcraft M, Tonmukayakul U, Manton D, Marwaha P, Stranieri A, et al. Teleconsultation/Telediagnosis using Teledentistry Technology: a Pilot Feasibility Study. Int J Adv Life Sci. 2014;6(3):291–9.

113. Queyroux A, Saricassapian B, Herzog D, Müller K, Herafa I, Ducoux D, et al. Accuracy of Teledentistry for Diagnosing Dental Pathology Using Direct Examination as a Gold Standard: Results of the Tel-e-dent Study of Older Adults Living in Nursing Homes. J Am Med Dir Assoc. 2017;18(6):528–32.

114. Forgie AH, Pine CM, Pitts NB. The assessment of an intraoral video camera as an aid to occlusal caries detection. Int Dent J. 2003 Feb 1;53(1):3–6.

115. Inquimbert C, Hirata-Tsuchiya S, Yoshii S, Molinari N, Nogue E, Roy C, et al. Concordance study between regular face-to-face dental diagnosis and dental telediagnosis using fluorescence. J Telemed Telecare. 2021;27(8):509–17.

116. Karthikayan R, Sukumaran A, Diwakar M, Raj Vb. Accuracy of smartphone based photography in screening for potentially malignant lesions among a rural population in Tamil Nadu: A cross-sectional study. Digit Med. 2019;5(2):56–61.

117. Estai M, Winters J, Kanagasingam Y, Shiikha J, Checker H, Kruger E, et al. Validity and reliability of remote dental screening by different oral health professionals using a store-and-forward telehealth model. Br Dent J. 2016;221(7):411–4.

118. Zafersoy-Akarslan Z, Erten H, Uzun Ö, Semiz M. Reproducibility and Agreement of Clinical Diagnosis of Occlusal Caries Using Unaided Visual Examination and Operating Microscope. JCDA. 2009;75(6):455a-455d.

119. Boye U, Pretty IA, Tickle M, Walsh T. Comparison of caries detection methods using varying numbers of intraoral digital photographs with visual examination for epidemiology in children. BMC Oral Health. 2013;13(1):1–11.

120. Mazur M, Jedliński M, Ndokaj A, Corridore D, Maruotti A, Ottolenghi L, et al. Diagnostic Drama. Use of ICDAS II and Fluorescence-Based Intraoral Camera in Early Occlusal Caries Detection: A Clinical Study. Int J Environ Res Public Heal 2020, Vol 17, Page 2937. 2020 Apr 24;17(8):2937.

121. Giraudeau N. e-Health Care in Dentistry and Oral Medicine. A Clinician's Guide. Springer; 2018.

122. Palta A, Gulrez M, Sharma B, Vats V, Sachdeva A. Role of teledentistry in dental care. J Dent Spec. 2022;10(1):3–7.

123. Jha K, Mandal Y, Avinash J, Kumar G, Vinay S. Teledentistry Through Web Apps And IODT - Reforming Dental Care In The Covid-19 Era. IOTA. 2021;1(3):198–208.

124. Ojima M, Hanioka T, Kuboniwa M, Nagata H, Shizukuishi S. Development of Web-based intervention system for periodontal health: A pilot study in the workplace. Med Inform Internet Med. 2003;28(4):291–8.

125. Smith RN, Rawlinson A, Lath DL, Brook AH. A digital SLR or intraoral camera: Preference for acquisition within an image analysis system for measurement of disclosed dental plaque area within clinical trials. J Periodontal Res. 2006;41(1):55–61.

126. Martins CC, Chalub L, Lima-Arsati YB, Pordeus IA, Paiva SM. Agreement in the diagnosis of dental fluorosis in central incisors performed by a standardized photographic method and clinical examination. Cad Saude Publica. 2009;25(5):1017–24.

127. Al-Malik MI, Holt RD, Bedi R. Clinical and photographic assessment of erosion in

2-5-year-old children in Saudi Arabia. Community Dent Health. 2001;18(4):232—235.

128. Estai M, Winters J, Kanagasingam Y, Shiikha J, Checker H, Kruger E, et al. Remote dental screening by dental therapists. BDJ Team. 2016;3(10):1–5.

129. Chen Y, Lee W, Ferretti G, Slayton R, Nelson S. Detecting developmental defects of enamel in infants. J Public Heal Dent. 2013;73(3):204–9.

130. Golkari A, Sabokseir A, Pakshir HR, Dean MC, Sheiham A, Watt RG. A comparison of photographic, replication and direct clinical examination methods for detecting developmental defects of enamel. BMC Oral Health. 2011;11(1):16.

131. Cruz-Orcutt N, Warren JJ, Broffitt B, Levy SM, Weber-Gasparoni K. Examiner reliability of fluorosis scoring: A comparison of photographic and clinical examination findings. J Public Health Dent. 2012;72(2):172–5.

132. Eswaran MA, Priya G, Maniselvan AB, Vishwani A, Khan T, Karthika R. Digital Dental Photography-A Modern Revolution. Indian J Forensic Med Toxicol. 2021;15(2):2742–50.

133. Gambino O, Lima F, Pirrone R, Ardizzone E, Campisi G, Di Fede O. A Teledentistry system for the second opinion. In: 2014 36th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBC 2014. IEEE Engineering; 2014. p. 1378–81.

134. Hardan L, Moussa C. Mobile dental photography: a simple technique for documentation and communication. Quintessence Int (Berl). 2020;51(6):510–8.

135. Daubländer M, Ph D. Intraoral Cameras as a Computer-Aided Diagnosis Tool for Root Canal Orifices. J Dent Educ. 2011;75(11):1452–7.

136. Castex D, Lisieux T, Calandro L. the intraoral video camera: A diagnostic tool in the exam of patient with increased oral cancer risk. Rev Clín Pesq Odontol, Curitiba. 2010;6(1):49–55.

137. Blomstrand L, Sand LP, Gullbrandsson L, Eklund B, Kildal M, Hirsch JM. Telemedicine-a complement to traditional referrals in oral medicine. Telemed e-Health. 2012;18(7):549–53.

APPENDIX A

IRB APPROVAL

THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

Office of the Institutional Review Board for Human Use

470 Administration Building
701 20th Street South
Birmingham, AL 35294-0104
205.934.3789 | Fax 205.934.1301 | irb@uab.edu

APPROVAL LETTER

TO: Montoya, Maria F

FROM: University of Alabama at Birmingham Institutional Review Board
Federalwide Assurance # FWA00005960
IORG Registration # IRB00000196 (IRB 01)
IORG Registration # IRB00000726 (IRB 02)
IORG Registration # IRB00012550 (IRB 03)

DATE: 28-Feb-2022

RE: IRB-300008370
IRB-300008370-005
Diagnostic Outcomes from a Dentist's Exams via Dental Auxiliary Obtained Digital Images

---

The IRB reviewed and approved the Initial Application submitted on 16-Feb-2022 for the above referenced project. The review was conducted in accordance with UAB's Assurance of Compliance approved by the Department of Health and Human Services.

Type of Review: Expedited
Expedited Categories: 4, 6
Determination: Approved
Approval Date: 28-Feb-2022
Approval Period: Expedited Status Update (ESU)
Expiration Date: 23-Feb-2025

Although annual continuing review is not required for this project, the principal investigator is still responsible for (1) obtaining IRB approval for any modifications before implementing those changes except when necessary to eliminate apparent immediate hazards to the subject, and (2) submitting reportable problems to the IRB. Please see the IRB Guidebook for more information on these topics.

APPENDIX B

WHO DENTAL CHART MODIFIED FORM

Diagnostic outcomes of digital images for comprehensive examination in pediatric dentistry: an Intra-examiner agreement assessment

Patient ID #: ☐ In Situ Exam

Examiner: ☐ Digital Exam

Examination Date: / /

HARD TISSUE FINDINGS

Recession(mm)																
	1	2	3	4 A	5 B	6 C	7 D	8 E	9 F	10 G	11 H	12 I	13 J	14	15	16
Bruxism/Erosion																
Bruxism/Erosion																
	32	31	30	T 29	S 28	R 27	Q 26	P 25	O 24	N 23	M 22	L 21	K 20	19	18	17
Recession(mm)																

OCCLUSION

Molar Relationship		Canine Relationship	Midline	Overjet (mm)	Overbite (%)
☐Class I	☐Mesial Step	☐Class I	☐Normal		
☐Class II	☐Distal Step	☐Class II	☐Shifted: Direction ______		
☐Class III	☐Flush	☐Class III			

SOFT TISSUE EXAMINATION

Soft tissue:						
	Lips	☐WNL	☐abnormal	Tongue	☐WNL	☐abnormal
	Buccal mucosa	☐WNL	☐abnormal	Floor of mouth	☐WNL	☐abnormal
	Palate	☐WNL	☐abnormal			

Findings:	None	Slight	Moderate	Heavy	Unable to assess	**Abnormal findings:**
Plaque:	☐	☐	☐	☐	☐	
Calculus:	☐	☐	☐	☐	☐	
Staining:	☐	☐	☐	☐	☐	
Gingivitis:	☐	☐	☐	☐	☐	
Periodontitis:	☐	☐	☐	☐	☐	

Additional Notes: