Scientific Article

Dental Screening of Preschool Children Using Teledentistry: A Feasibility Study

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Abstract: ***Purpose:*** *The purpose of this study was to assess the feasibility and reliability of using intraoral cameras and telehealth communication technology to screen preschool children for oral disease, in particular early childhood caries (ECC).* ***Methods:*** *The authors used the existing infrastructure of the Health-e-Access telehealth Network to: (1) assess the diagnostic quality of dental images using the Dr. Camscope intraoral camera; and (2) compare the resulting images to a traditional oral examination. A calibrated dental examiner observed 50 preschool children 4 to 6 years old who were enrolled in an inner-city childcare center. Following the oral examination, images of the children's teeth were obtained by a trained telehealth assistant and transmitted to the remote site computer; identifiers were removed and the images were randomized. After a 2-week washout period, the images were read by the same examiner.* ***Results:*** *A complete set of dental images was obtained from all 50 children in the study. A greater proportion of children examined using the intraoral camera were observed to have caries (42%) compared to children examined visually (28%). Furthermore, a greater number of carious teeth were detected from the images than from the visual examinations. The mean teledentistry dfs score was 2.10, and the oral examination 1.50 (P>.05). The kappa agreement was 61 (κ=0.61; 95% CI=0.39-0.89).* ***Conclusions:*** *There was no statistically significant difference between a visual examination and an examination using an intraoral camera, thus suggesting that the intraoral camera is a feasible and potentially cost-effective alternative to a visual oral examination for caries screening, especially early childhood caries, in preschool children attending childcare centers. (Pediatr Dent 2007;29:209-13)*

KEYWORDS: EARLY CHILDHOOD CARIES, INTRAORAL CAMERA, TELEDENTISTRY, DENTAL SCREENING, PRESCHOOL CHILDREN

Telehealth, also referred to as telemedicine, has been used successfully in many medical specialties for: (1) diagnosis; (2) consultation; and (3) treatment of acute and chronic diseases in children and adults. It is prevalent in: (1) rural communities; (2) medically underserved areas; and (3) inner-city clinics in this country and others.[1] Radiology reports are transmitted readily by using secure, low bandwidth messaging systems.[1] Dermatologists and cardiologists, among other specialties, have embraced telehealth as a tool for medical diagnosis.[2,3] In dermatology, sophisticated cameras attached to telehealth systems are used to obtain images. Overall, patients seem to accept teledermatology and are satisfied with it as a way of obtaining health care.[3]

In cardiology, electronic stethoscopes facilitate transmission of heart sounds with outstanding reliability.[2] Electrocardiograms, echocardiograms, and ultrasonographic images can be transmitted easily electronically and evaluated accurately.[4] Tele-echocardiology has the potential to guide immediate treatment changes for neonates. Emergency consultations conducted between remote rural general emergency departments and academic centers have been documented as successful and feasible.[4,5] Telehealth has been used in neonatal intensive care units to allow families separated from their infants to keep them updated on their children's condition and to view images of their infants while they are in the hospital.[6] Great advances in the area of telehealth have created opportunities to use this technology to improve health care access and to reach underserved populations.[7] Telehealth has been suggested as a means to overcome socioeconomic barriers and social distance that inhibit access to the health care system in urban dwelling populations.[8] It can be used for both routine communications between the physician and the telehealth assistant and can address urgent concerns. The benefits of telehealth to children and parents include:

1. improved access;
2. earlier diagnosis and treatment;
3. reduced time lost from work;
4. avoidance of stress associated with transportation;
5. enhanced continuity of care; and
6. ability to receive specialty care in one's own community.[9]

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The Health-e-Access Childcare Telehealth Network project has shown that telehealth reduced absence due to illness in urban childcare by 63%.[10]

Although medicine has utilized telehealth for over 30 years for diagnosis, consultation, and treatment, dentistry has not. Dental practitioners have used intraoral cameras mainly for patient education. Telehealth technology has not yet been as widely used or accepted in dentistry as it has in medicine. The purpose of this study was to evaluate whether the use of telehealth communication technology and intraoral cameras for oral screenings of preschool children for dental caries would be comparable to visual oral examinations.

Methods

A school- and childcare-based telehealth network has been successfully developed to reach inner-city children in the Rochester, NY, metropolitan area. Since May 2001, pediatricians from the School of Medicine and Dentistry at the University of Rochester, Rochester, NY, have been using commercially available technology that enables physicians to evaluate and treat ill children at distant childcare and elementary school sites. Medical peripheral devices allow for: (1) complete ear, nose, and throat exams; (2) detailed examination of the skin; and (3) transfer of electronic stethoscope sounds.

The Health-e-Access program, which began in inner-city childcare centers, currently operates in 20 different childcare programs or elementary schools in both inner-city and suburban areas. Telehealth service is now provided by a group of 9 participating primary care physician practices, including over 30 clinicians. The existing infrastructure of Health-e-Access was used to assess the diagnostic quality of dental images using the Dr. Camscope intraoral camera (Sometech Inc, Seoul,Korea) and to compare the resulting images to a traditional visual oral examination. Children enrolled in this study lived in the most impoverished area of Rochester, NY, and annual oral health surveillance studies have consistently identified high caries rates in elementary schoolchildren who live in the inner-city area of Rochester.

Conversely, no data were available on the caries status of preschool children. Anecdotal reports suggested that a high prevalence of oral disease existed in this population of very young children. The procedures, possible risks, and benefits were explained to parents of the participating children, and their informed consent was obtained prior to the study. The University of Rochester Medical Center Research Subject Review Board (RSRB) approved the study prior to its initiation. The authors chose the Dundee Selectable Threshold Method (DSTM) as the index to quantify results of the caries examination.[11,12] The teeth were dried with cotton rolls, and the examiner visually examined the teeth using a plane mirror only; dental explorers were not used. Decayed and filled surfaces (dfs) were recorded on individualized, prelabeled caries exam forms for both the visual and teledentistry examination; dfs scores were calculated for each child.

A single dental examiner was calibrated with a gold standard dental examiner on the DSTM. The calibrated dental examiner subsequently examined a convenience sample of 50 preschool children 4 to 6 years old who were enrolled in an inner-city childcare center. Following the oral examination, images of the children's teeth were obtained by a trained telehealth assistant, and the recorded digital images were transmitted via a secure Internet connection to a dedicated computer at the remote dental site (Eastman Department of Dentistry, Division of Community Dentistry and Oral Disease Prevention, University of Rochester). For study purposes, identifiers were then removed and the images were randomized. After a 2-week washout period, the images were read by the same examiner.

The Health-e-Access telehealth program has trained and certified childcare center employees as telehealth assistants (TAs). The TAs at the daycare center where the teledentistry pilot study was conducted were trained by the study's principal investigator to image children's teeth for a dental assessment. Six images of the labial/buccal and occlusal surfaces of each child's teeth were recorded, including 2 anterior and 4 posterior views. Additional views of the posterior buccal/facial surfaces and anterior/posterior lingual surfaces were obtained as necessary or appropriate if these were not otherwise visible.

As the primary measure, each child was scored as having caries experience or not (dfs>0 or dfs=0). The diagnostic quality of the digital images was assessed by comparing the traditional oral examination to the images obtained using the intraoral camera. Validity was assessed by visually re-examining 5 children observed to have caries lesions on images that were not observed visually. In each instance, the digital image was correct. Conversely, all caries lesions observed on the imaged teeth were also observed visually. As an index of reliability, a kappa statistic was calculated to assess the agreement between the 2 examination types. A paired t test was applied to assess the differences in mean dfs scores between the oral examinations and teledentistry images. Sensitivity and specificity of the teledentistry images were calculated using the oral examination as the gold standard.

Results

Fifty preschool children between 4 and 6 years old who were enrolled in a selected inner-city childcare center participated in the study. Of these, 14 children were 4 years old, 34 were 5 years old, and 2 were 6 years old. This sample was equally divided between males and females. The majority of children

Table 1. PERCENTAGE OF CHILDREN IDENTIFIED AS CARIES-EXPERIENCED BY AN INTRAORAL CAMERA AND A TRADITIONAL VISUAL ORAL EXAMINATION

	No. of children in the study	% of children identified as caries-experienced	Mean dfs (±SD)	Paired *t* test (P-values)
	N=50	42% (via intraoral camera)	2.10±3.43 (via intraoral camera)	.056
		28% (via traditional exam)	1.50±2.79 (via traditional exam)	
Gender	Female (N=25)	44% (via intraoral camera)	1.76±2.76 (via intraoral camera)	.061
		32% (via traditional exam)	1.44±2.60 (via traditional exam)	
	Male (N=25)	40% (via intraoral camera)	2.44±4.02 (via intraoral camera)	.648
		24% (via traditional exam)	1.56±3.03 (via traditional exam)	

in the study were African American (N=37), followed by Hispanic (N=8), Caucasian (N=3), and Asian (N=2).

Caries prevalence was 28% (N=14) for the visual examination (32% males; 24% females) and 42% (N=21) for the teledentistry examination (40% males; 44% females). The kappa agreement was 61 (K=0.61; 95% CI 0.39, 0.83).

The data from this study, shown by age and gender, are presented in Table 1. The number of decayed and filled surfaces (dfs) was recorded for each child. The mean dfs score was 2.10 (3.43 SD) for the teledentistry examination and 1.50 (2.79 SD) for the visual examination (P>.05).

Sensitivity of the teledentistry examination was 100%, and specificity was 81%. Table 2 represents the 2x2 table that was used to calculate sensitivity and specificity of the teledentistry examinations, given that the oral examination was used as the gold standard. Each child was the unit of analysis.

Discussion

This study's results revealed that almost half of the inner-city children examined were diagnosed with dental caries by the teledentistry examinations, mainly ECC. In many of these children, multiple primary teeth were affected, and there were no negligible signs of dental treatment. In the judgment of the examiner, the diagnostic quality of digital images was superior to visual inspection. Figure 1 is a typical example of teledentistry images obtained during the study.

The kappa statistic between traditional oral dental examinations and teledentistry examinations was 61, indicating a good agreement between the 2 examination types.[13] The mean dfs scores for the teledentistry images and the visual examinations were not statistically different (P>.05), suggesting that teledentistry would be a useful and potentially cost-effective measure for screening large numbers of preschool children in daycare for early signs of caries activity, especially ECC.

The teledentistry examinations showed more children as having caries experience than traditional clinical oral examinations. This was due in part to the illumination and magnification of the tooth surfaces by the intraoral camera. Moreover, the intraoral camera is more sensitive to ultraviolet and infrared light than the human eye due to a greater spectral sensitivity range. Most likely, the disagreement on caries diagnosis between teledentistry imaging and the traditional oral examination was attributable to the greater spectral sensitivity and illumination of the oral cavity by the intraoral camera. Imaging of the child's mouth provides high quality pictures for deliberate evaluation. The physical oral inspection of the child's mouth, however, is often impeded by the child's ability to cooperate—especially in a field examination scenario.

Figure 1. Examples of the Teledentistry images

Table 2. 2X2 TABLE INDICATING POSSIBLE GROUPS RESULTING FROM TELEDENTISTRY EXAMINATIONS GIVEN THAT ORAL CLINICAL EXAMINATIONS WERE USED AS THE GOOD STANDARD*

TEST RESULT	CHILDREN WITHOUT CARIES EXPERIENCE	CHILDREN WITHOUT CARIES EXPERIENCE	
Positive screening	14 True Positives (TP)	7 False Positives (FP)	21
Negative screening	0 False Negatives (FN)	29 True Negatives (TN)	29
	14	36	50

* Sensitivity=TP/TP+FN 14/14=100%; specificity=TN/TN+FP 29/36=81%.

Nevertheless, it seems reasonable that, in cases of disagreement, teledentistry images may offer superior visualization of the oral cavity compared to the views available during a clinical dental examination. Indeed, that is what the authors observed when sensitivity and specificity were calculated. The Teledentistry examinations to yield more false positives than the clinical oral examinations (Table 2). However, the false positives were the result of being able to see the lesions on the images, but not visually. Subsequently, the presence of the lesions was verified clinically. Neither oral examinations nor teledentistry images were able to detect interproximal caries lesions that were not otherwise visible.

Teledentistry may be quite useful as a means to screen children for signs and symptoms of oral disease. Unlike medicine, however, treatment cannot be prescribed remotely, as the child needing oral health care must still be referred to a dentist. This limitation not withstanding, however, teledentistry still offers a practical and potentially cost-effective means to screen large numbers of children in field surveys of oral health.

One of its main uses may be in the public health domain. For example, in a similar pilot study conducted by the Telehealth Center of the University of Alberta, Edmonton, Alberta, Canada, a total of 137 schoolchildren were screened using traditional methods. Two months later, 32 children were randomly selected and rescreened in a single day using the intraoral camera. A comparison of the 2 methods showed no significant difference in data collected in the study. The kappa statistic ranged from 0.50 to 1.0 for different measurement categories. The authors concluded that the telehealth system showed great potential to identify oral conditions accurately and could serve as a means of consultation among specialists, general dentists, dental hygienists, and patients separated by great distances and especially in rural areas.[14]

As this feasibility study demonstrated, the process of obtaining images is noninvasive and less stressful for small children than the usual oral examination. Increased child comfort is especially likely when the teledentistry exam is conducted in a familiar environment by familiar childcare or school staff, as was the case for this study. Children who participated in the study were enthusiastic and cooperative during the imaging and recording procedures.

As the authors observed in this study, the advantages of teledentistry screenings are:

1. Images can be sent to a remote location for analysis, diagnosis, and referral.
2. Digital images of poor or no diagnostic quality can be easily repeated and accessed as many times as needed, as they can be stored in a computer database, on a CD, or in some other suitable storage medium.
3. Children can be re-examined easily to determine if treatment has been rendered.
4. The telehealth assistant is in close contact with the dentist if emergency evaluation is needed.
5. Teledentistry has the potential to save time and re sources and to enhance access to care.
6. Teledentistry may be especially useful in remote rural areas and in other areas where there are few dental practitioners (ie, urban inner-city areas and federally designated "dental health professional shortage areas").

New approaches and additional efforts are needed to improve the dental health of preschool children, particularly children without adequate access to dental care. Teledentistry has the potential to integrate oral health into the larger health care delivery system by fostering enhanced interpersonal communications with other health care professionals such as: (1) pediatricians; (2) radiologists; and (3) nutritionists.[15] Teledentistry has the potential to reduce:

1. waiting times for consultation; and
2. travel times to a remote hospital, clinic, or dental office.

Consultation may take place with the patient and the referring practitioner, nurse, dental hygienist, or telehealth aid in the dental office, school, childcare center, or other facility equipped with intraoral cameras. A survey of rural and urban

Scottish dentists suggested that dental practices in rural areas do not have equal access to referral services. Rural dental practitioners did not refer for a second opinion as readily as their colleagues in areas closer to hospitals or specialist offices.[16]

Teledentistry has the potential to serve rural dental practitioners to facilitate secondary dental care. Further studies are indicated to assess the full capability and cost-effectiveness of teledentistry, particularly in the public health domain as a means to screen large numbers of preschool- and school-age children for signs of oral disease and to improve access to care for children who would otherwise not receive care at an early age.

Conclusions

Based on this study's results, we concluded that:

1. The intraoral camera is a feasible alternative to a visual oral examination for caries screening, especially early childhood caries, in preschool children attending childcare centers.

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