Using Teledentistry to Improve Access to Dental Care for the Underserved

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Advances in dental care have documented that early diagnosis, preventive treatments, and early intervention can prevent or reduce the progress of most oral diseases, conditions that, when left untreated, can have painful, disfiguring, and lasting negative health consequences.[1] Unfortunately, millions of American children and adults lack regular access to routine dental care, and many of them suffer needlessly with disease that inevitably results in significant decrements in their quality of life. Problems in access to oral health care cut across economic, geographic, and ethnographic lines. Racial and ethnic minorities, people who have disabilities, and those from low-income families, particularly children, are especially hard hit. In most rural areas in this country, especially, there are many barriers to dental health care, including geographic remoteness, sparse population, adverse seasonal weather and road conditions, poor or no public transportation, poverty and lack of health insurance, a less mobile aging population, culturally specific health care needs of many groups (especially American Indian and immigrant populations); a low number of dentists relative to total population, and a scarcity of specialty and subspecialty dentists.

Teledentistry is an exciting new area of dentistry that uses electronic health records, telecommunications technology, digital imaging, and the Internet to link health care providers in rural or remote communities to enhance communication, the exchange of health information, and access to care for underserved patients. This article

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discusses how innovative health information and communication technologies can improve access to oral health care through teledentistry.

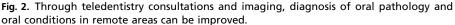## WHAT IS TELEDENTISTRY AND HOW DOES IT WORK?

Teledentistry uses electronic health records, telecommunications technology, digital imaging, and the Internet to provide teleconsultation with specialists, supervision of collaborative hygienists in remote areas, and education. Teleconsultation can take on two forms. Real-time consultation uses direct on-line computer video telecommunication between a dentist, hygienist, or patient in a remote community and a dentist or specialist in a larger community who provides support or supervision. In the "store and forward" method, electronic health records and videos store data that can be retrieved and reviewed by the specialist who renders an opinion (**Figs. 1** and **2**).

Telehealth projects, including telemedicine and teledentistry, have been implemented as models to improve education and access to care.[2–25] Telehealth has been used in various demonstration projects throughout the nation and has been shown to be particularly helpful in remote and rural areas where access to specialists is limited.[2–8] For example, Total Dental Access is the teledentistry project within the Department of Defense[2] that enables referring dentists from the US Armed Forces to consult with specialists at a medical center on the status of a patient. Total Dental Access focuses on three areas of dentistry: patient care, continuing education, and dentist–laboratory communications. This project has demonstrated increased patient access to dental care and the cost effectiveness of a Web-based system. The Children's Hospital Los Angeles Teledentistry Project, developed in association with the University of Southern California's Mobile Dental Clinic, increases and enhances the quality of oral health care provided to children living in remote rural areas of California, areas often severely underserved by dental health providers.[7] A 12-month trial of teledentistry was conducted in two general dental practices in remote sites in Scotland.[5] The dental practices had a personal computer (PC)-based videoconferencing link connected by an Integrated Services Digital Network (ISDN) at 128 kbit/s to a restorative specialist at a central hospital. Twenty-five patients were recruited into the trial. A cost-minimization analysis was undertaken by comparing the costs of teledentistry with two alternatives: outreach visits, in which the specialist regularly visited the remote communities, and hospital visits, where patients in remote communities traveled to hospital for consultation. The study found the cost savings of teledentistry were

Fig. 1. Dentists and dental hygienist in remote areas can link to specialists in larger communities through teledentistry.

Fig. 2. Through teledentistry consultations and imaging, diagnosis of oral pathology and oral conditions in remote areas can be improved.

greatest in the remote communities, where patients otherwise would have had to travel long distances for specialist consultations.

For a typical teledentistry visit, special videoconference equipment and a video/ Internet connection are set up at both the hub site and the remote site. The patient checks in at the remote clinic and before the consultation fills out questionnaires, either on paper or on line, regarding chief complaints and medical and dental history. The dentist or a member of the dental team (assistant or hygienist) at the remote clinic facilitates and records a hands-on examination (see **Fig. 2**). (This examination may take place either during the visit or earlier, when a teleconsultation is requested.) The questionnaire, examination, and any imaging or documents that are included in the dental record are transmitted to the hub (eg, to a university specialist) via the online electronic patient record system. With this information in hand and reviewed, the specialist starts a live consultation with the patient through videoconferencing (**Fig. 3**).

The live video-consultation is similar to a live in-person consultation (see **Fig. 1**). The dentist interviews the patient, asks questions, discusses the diagnosis and treatment, and educates the patient about the condition. In some situations, the dentists may ask the patient to open the mouth to determine function or measure the opening in front of the camera. In other cases, the dentist reviews the images and examination findings presented in the electronic record on a split screen with the teleconsultation and reviews this information with the patient. In all cases, patients need to feel connected to the dentist performing the consultation, as if the dentist were standing next to the patient.

A major challenge in a teledentistry visit is the collaboration between the hub site and the remote site. **Fig. 3** illustrates the process for communicating between the remote site and the specialist clinic site. Because the consultation is "remote" in nature, the dental teams at both sites must collaborate constantly for a smooth tele- dentistry process. The challenge begins with making the concurrent appointment at both sites, progresses through the collection of patient information and its transmittal to the specialist, facilitating the "remote" real-time examination, and ends with facili- tating the plan for treatment and future care. Because the specialist cannot perform a hands-on examination, he/she must rely on the examination performed by the dental team at the remote site. Confidence and good working relationships between team members at both sites must be established. As in any other learning processes, appropriate training, practice, and patience are essential for a satisfactory result.
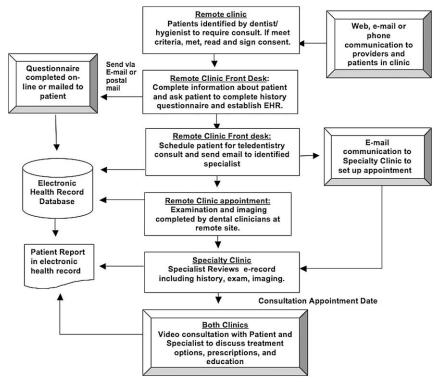
Fig. 3. Procedures followed in the recruiting patients in the dental office and obtaining consultation, illustrating the process for communicating between the remote site and the specialist clinic site.

With hands-on training and repeated practice, the dental teams at both sites can establish a reliable network for teledentistry.

THE UNIVERSITY OF MINNESOTA TELEDENTISTRY PROJECT

A teledentistry network has been established that links specialists at the University of Minnesota School of Dentistry to dentists and patients in remote rural areas where access to care is difficult. The network also increases training for dentists and dental students in the rural community in the management of orofacial disorders.[9] Minnesota traditionally has been a state with a high level of awareness regarding dental and health matters and ranks above the national average in access to health care. There are, however, special populations and several geographic areas in the state where the picture is not so bright and where barriers to quality dental care are many, including geographic remoteness and sparse population. Teledentistry has improved this situation by expanding the access of rural and underserved populations to care through electronic communication.

The teledentistry network was established in 2004 linking the University of Minnesota School of Dentistry specialists with dentists and patients in remote rural areas. The first demonstration site was implemented at the Hibbing Community College Dental Clinic. This clinic is located approximately 200 miles north of Minneapolis and is a joint

venture with the Hibbing Community College. The patient population consists primarily of low-income families in St. Louis, Lake, Cook, and Carlton Counties. The clinic is staffed by dental students with supervision from faculty to provide clinical training in rural areas of Minnesota. In their junior and senior years, all dental students rotate through this clinic; at any given time, four to six students provide care to the patient population. This clinic provides care for patients who have medical assistance from states and Medicaid.

Currently, the teledentistry system provides consultations to the demonstration site for temporomandibular disorder, orofacial pain, and oral medicine. The preliminary testing and evaluation of the system revealed high levels of acceptance and satisfaction from both providers and patients. In more than 90% of the visits, specialists were satisfied with the teledentistry consultation. In 94% of the visits, providers were as confident about providing adequate diagnosis and treatment planning as in a face-to-face visit. In 83% of the cases, providers thought that patient assessment using teledentistry was as complete as in a regular visit.

One challenge in a teledentistry visit is the possible increased time needed to perform a consultation. In the majority of the visits (61%), providers reported using about the same amount of time as in a regular in-office visit, but in 33% of the visits providers thought that teledentistry visits were more time-consuming. This problem is encountered particularly when the providers are learning to use the system. With experience, skills improve, and work is performed more efficiently.

Patients expressed high levels of satisfaction with the teledentistry service. The greatest benefits that the teledentistry network offers patients are convenience and access to care. Since the program started, approximately 13 patients have made 24 teledentistry visits through the course of their care. The patient satisfaction study showed that, instead of driving 200 to 300 miles each way to the University for care, the average distance for visiting the teledentistry clinic is only 13 miles. On average, a teledentistry visit requires less than 2 hours, compared with 18 hours if the patient had to travel to Minneapolis for the visit (**Table 1**). Specialists who can treat orofacial disorders such as temporomandibular disorder, orofacial pain, and oral medicine rarely are found in local rural communities. These disorders usually are chronic conditions that require repetitive visits and ongoing care. Many patients commented on the teledentistry service as being "convenient," "effective," "saving on travel time," requiring "less time out of [the patient's]schedule," and being "easier to reach."

In addition to providing greater convenience in accessing care, teledentistry also effectively meets patients' goals in seeking care. The average rating of teledentistry in meeting a patient's goal for a visit is 9.1 (with 10 being the best possible). The patients' overall satisfaction that the teledentistry clinic met their current health care needs was rated as 6.84 on average (with 1 = not satisfied at all and 7 = completely satisfied). When considering their experience with teledentistry visits, most patients

Table 1		
Comparison between teledentistry visits and regular office visits		
Distance Traveled and Time Spent by Patient	Teledentistry Clinic	University of Minnesota School of Dentistry Specialty Clinic
Travel distance to clinic (average, one-way, in miles)	12.6	230.3
Time missing from work/school (average, in hours)	1.6	18.3

felt comfortable in visiting the doctor through the videoconference service. In fact, many patients felt that the teledentistry visit was "the same as in an office or in person," except that it was "just through the TV." When patients were asked if they would prefer to see the doctor in person, half of the participants said "no" because they perceived no need for doing so. Some patients felt that seeing the doctor in person "would always be the best" but "this [teledentistry] works well, too."

Many patients who used the teledentistry service expressed their appreciation for and satisfaction with the program. Patients commented that teledentistry is a "wonderful service to provide to patients of rural areas … to give the knowledge and expert advice of the specialists via teledentistry is such a convenience"; "thank you for giving us big city help in a rural area"; "I feel that many people would benefit from this kind of dentistry if it was available"; "I love this system. It has made getting care easier and more convenient." As a result, all participants said they would use the teledentistry service again. Some patients recommended the service to their relatives and friends.

AREAS IN WHICH TELEDENTISTRY HAS BEEN HELPFUL IN IMPROVING ACCESS TO CARE

Several areas in dentistry that are particularly appropriate for teledentistry are remote consultations for orofacial disorders, collaborative hygienists' visits in remote areas, and continuing education. Future uses of teledentistry in medicine, such as clinical decision support, consumer home use, medication e-prescribing, and simulation training, will expand as the technology and applications for dentists increase.[15–25]

Remote Consultations for Care for Orofacial Disorders

Orofacial disorders include oral cancer, temporomandibular disorders, oral mucosal disease, salivary gland disorders, orofacial pain disorders, oral neurosensory disturbances, orofacial dystonias and dyskinesias, bruxism, burning mouth, dental sleep disorders, malodor, and dental phobias. With a collective prevalence of more than 40% of the population (**Table 2**),[26–30] the need for treatment of temporomandibular disorders alone is comparable to back pain, dental caries, and periodontal disease.[27] In addition, because orofacial structures have close associations with that functions of eating, communication, sight, and hearing, as well as affecting appearance, self-esteem and expression, persistent pain of orofacial origin can adversely affect an individual's overall quality of life.[3]

Most general dentists and dental specialists feel inadequately trained to recognize and manage these problems, for several reasons, including inadequate clinical and didactic training in dental school, lack of knowledge about appropriate medical billing procedures and codes, and the different office protocols that require more time. The complexity and difficulty of managing orofacial disorders usually results in a consultation with or referral to a specialist. Teledentistry can bring the specialist in orofacial pain or oral medicine to the rural dentist or dental hygienist through remote teleconsultations. These common conditions require intense patient care and can be reimbursed by medical insurance.

If the recognition and treatment of the orofacial disorders are inadequate or inappropriate, the personal impact can be tragic, and the costs are great. Numerous studies have shown that patients who have chronic orofacial pain disorders do not receive adequate early care. When chronic pain persists, it can become entrenched in the patient's life with the development of dependent relationships, emotional disturbances, disability, and many behavioral and psychosocial problems. These disorders present a frustrating medical and dental picture with patients undergoing costly

Table 2
Common medical-dental problems that require consultation, billing with medical fees and insurance, and special treatment needs

Orofacial Disorders	Need for Treatment (%)	Treatment
Temporomandibular disorders	5–7	Splints, physical therapy, behavioral, pharmacologic, surgical
Orofacial pain disorders (neuropathic/vascular, atypical, and others)	2–3	Pharmacologic, behavioral, surgical
Benign masticatory headache	15–20	Splints, physical therapy, behavioral, pharmacologic
Sleep apnea and snoring	5	Oral and nasal appliances, surgery
Neurosensory disorders (taste and chemosensory, orofacial paresthesias)	0.1	Pharmacologic and behavioral
Orofacial dystonias/dyskinesias	0.1	Splints, physical therapy, behavioral, pharmacologic
Bruxism and oral habits	10+	Behavioral and pharmacologic
Dental phobia/anxiety	2–5	Behavioral and pharmacologic
Oral lesion (herpes, aphthous, pre-cancer)	3–5	Biopsy and surgery
Oral mucosal disease (eg, lichen planus, *Candida*)	5–8	Biopsy, pharmacologic, and behavioral
Xerostomia and salivary gland disorders	8–10	Pharmacologic and behavioral
Burning mouth and tongue	0.5	Pharmacologic and behavioral
Malodor	5–8	Behavioral and pharmacologic
Medically compromised patients	10–15	Considerations during dental treatment

treatments, diagnostic tests, long-term medications, and an ongoing dependency on the health care system.[30] Furthermore, dissemination of scientific knowledge about these disorders to the clinical community is poor, and the need for clinical consultations is high. More effort also must be spent in clinical training to ensure these patients receive access to high-quality care. Access to care for these problems should be expanded in the community and particularly in rural and underserved areas. Teledentistry allows these patients to see a specialist in a city or university without driving for hours to the appointment.

Teledentistry and Support of Collaborative Dental Hygienists

Teledentistry also can increase access to preventive and diagnostic care for patients in remote and underserved areas by supporting community-based collaborative

hygienists. Hygienists already are well trained to be frontline oral health practitioners in new models of delivery of dental care. They are optimally skilled in patient education, prevention, assessment, and triaging care as members of a collaborative oral health team. Dental hygienists in remote and underserved areas can provide local cost-effective access to dental evaluations, preventive care, and education while being supported through teledentistry by dentists and dental specialists in a nearby community. This technology allows regular communication, support, and supervision, as well as facilitating teleconsultations for orofacial disorders and referrals for restorative, periodontal, oral surgery, and other dental care.

For the patient located in an underserved or remote area, hygienists supported by teledentistry can provide more accessible and less expensive preventive dental care and education. For a dental hygienist located in a remote or underserved area, teledentistry can provide direct support and supervision by a dentist in a nearby community or by specialists to facilitate evaluation, establishing diagnoses, and recommending treatment options and/or referral to appropriate care providers. For the dentist in the nearby community, teledentistry provides an opportunity to provide care to a patient who otherwise probably would not seek care. Teledentistry enables the specialist located many miles away at a university or specialty practice to make a diagnosis, recommend treatment options, and provide prescriptions and instructions about self-care.

Teledentistry and Dental Education

The teledentistry system also can provide a unique way to deliver long-distance clinical training and continuing education. Videoconferencing and Internet technologies allow low-cost, real-time interactive, two-way communication between instructors and trainees, making long-distance education more virtual and affordable. The videoconferencing system can be used both to train dentists and dental students at remote sites in conducting clinical examinations and to train dental assistants and other clinical support staff in clinic management issues (eg, scheduling, billing, and handling insurance issues). Through the videoconferencing system, professors of dentistry can collaborate with colleagues at other universities to exchange experiences with teledentistry systems. The responses from the participants are very positive. Teledentistry is more like a telephone service that has low technical requirements at the user end. The system provides easier and clearer communication than telephones because the users at both ends can communicate face-to-face.

The teledentistry videoconferencing system can be used to help train dentists, dental students, assistants, and other office support staff at remote sites in the clinical management of orofacial disorders and other conditions. Upon seeing a patient who has a complex orofacial disorder, the dentists can be trained to review the patient's history of illness, medical and dental history, and diagnostic studies, such as digital photographs or radiographs, to perform a disease-specific clinical examination, and then to consult with the specialist via teleconferencing on the diagnosis and the best course of management and treatment. The dentists or dental student then implements the treatment plan under the guidance of the specialist at the university. The advantages of using teledentistry by dentists and dental students in a rural community and of involving dental residents at the university are the improved access to specialists for clinical training, confirming diagnosis, and formulating a treatment plan; the reduced cost of oral health maintenance through shared resources; the reduced isolation of practitioners through contact with peers and specialists; and the improved quality of care.

Teledentistry also can provide multipoint interactive continuing education courses, multicenter treatment planning conferences, and inter-residency case reviews with community dentists at remote sites. As the project grows, teledentistry can provide long-distance ''hands-on'' training to local therapists at remote sites through the tele-dentistry videoconferencing network. Teledentistry provides practitioners with links to virtual dental health clinics and the growing network of providers who subscribe to a specific Web record service. In a time of increasing consolidation throughout the health care system, this ability could create an entire new view of dentistry. Multiple providers could create virtual care groups to provide expanded clinical training and could coordinate both care and also contracts for the delivery of services. This network of providers could coordinate the care of a single patient electronically, sharing a complete multimedia chart and all the documentation therein. Teledentistry also can facilitate patient education about self-care for the problem, allow e-mail follow-up on the status of the problem, and improve doctor–patient communication.

THE USE OF ELECTRONIC RECORDS FACILITATES TELEDENTISTRY

The evolution of electronic patient records has made teledentistry an immediate reality. Because an increasing number of dental care providers can access the Internet, traditional barriers to exchanging information have been reduced. Web-based records also make cumulative, longitudinal patient records possible. Well-tested security mechanisms have ensured the integrity and confidentiality of patient information. Because Web-based systems are simple to install and configure, the cost of operating them is less. Many dental schools are adapting these technologies to expand the services offered. This component configuration at the site for teledentistry should allow a practitioner to create a multimedia electronic health record that includes intraoral and exterior images, copies of handwritten paper-based patient records, charts, and diagrams, and virtually any other type of relevant patient data. New software that can compile all this information into a single electronic patient chart, encrypt the chart for security, and transfer the chart via the Internet is part of this record. This system streamlines the process of gathering and securing data, as well as communicating it via the Internet.

TELEHEALTH EQUIPMENT AND TRANSMISSION MODES

The technology for performing video consultations and telecommunication continues to improve. For example, the Sony PCS TL-50, Polycom VC2, and Tandberg systems are for higher-quality and routine commercial use. In addition, the use of PC-based videoconferencing systems such as iChat, Skype, Windows Live Messenger, and AOL Instant Messenger provide lower-cost solutions that communicate through broadband networks. Desktop conferencing is often referred to as ''PC-based video-conferencing'' or sometimes even ''video chatting.'' The average desktop confer-encing system consists of the individual person's desktop or laptop computer, a separate monitor if needed or available, a microphone, headset or external speakers, a software application that is capable of coding and decoding audio and video (codec), and a Webcam. Although the quality of the picture and transmission can be lower, a desktop conferencing system typically costs significantly less than the standard room-based system, so it can be available for many dentists to use. It has some limitations, however. The most notable limitation is that, because it is based on a desktop (or similar environment), the number of users who can participate from any one end point is limited by space, the camera view, the single headset, and the surrounding environment. Normally no more than two or three people can use

a desktop conferencing system, even if external speakers are used. A single patient and a dentist or hygienist should be able to participate with acceptable quality.

Teledentistry networks require encrypted transmission but can use a standard broadband Internet connection or specialized digital networks. Most networks are designed to be cost effective, to have high reliability, and are based on open architecture to allow connections between any network members as well as connections with non-network sites that use standards such as h.320 (via ISDN) or h.323 Internet Protocol (IP) standards. All teledentistry efforts need to provide sufficient security to meet Health Insurance Portability and Accountability Act (HIPAA), state, and member institution requirements. All teledentistry communications equipment should be based on h.323 IP standards for broadband residential service where available and secure.

HEALTH INSURANCE PORTABILITY AND ACCOUNTABILITY ACT AND SYSTEM SECURITY WITH TELEDENTISTRY

All members of a health care team and the teledentistry network are considered covered entities under HIPAA privacy regulations that became effective April 14, 2003. A clinic's computing hosting and facilities are considered confidential electronic patient records. A state-of-the-art computing facility is a requisite requirement for housing the databases of electronic dental records and teledentistry. The privacy, confidentiality, security, and secure back-up of data must meet HIPAA requirements and federal standards for system security. Both plans consider the storage and retrieval of patient demographic, medical history, examination, diagnosis, treatment information, and specimen storage information.

In most systems, dental records to be stored into an electronic database first must pass through several filters to get into the system. These filters provide security through firewalls and also screen data for completeness, consistency, and any irregularity. A number of methods are used to prevent unauthorized entry into the database: router filtering, user name and password protection, encryption of transferred data, internal versus external protocols, and a restricted secure file transfer protocol (SFTP). A system must serve as the initial Certificate Authority for the members of the network. Digital certificates contain a participant's identification, valid time period, public key, and other cryptographic information including the digital signature of the participant. Certificates are used to prevent hackers from entering the network by pretending to be one of the participants and must be changed periodically. The Certificates also serve to verify that the participants are authentic. The intranet system for each clinic staff uses Certificates including user log-in screens with a unique user identification and password. Once inside the intranet system, a Transaction Layer Security (TLS) or Secure Socket Layer (SSL) connection is established between each clinic and the host server to prevent outside hacking of the system. The use of digital certificates in TLS prevents eavesdroppers from monitoring data transfers. These common functions are standard in both Java and Microsoft environments. Passwords that are generated for participants are maintained as encrypted text in the database tables. Public or clinic system administrators do not have access to the security password tables. The passwords are decrypted in real time using an RD5 algorithm. Server authentication also uses the Microsoft/Microsoft Transaction Server security system, with access available via secure backdoor ports such as SFTP and direct Web scripting technologies.

SUMMARY

Teledentistry is a new area of dentistry that integrates electronic health records, telecommunications technology, digital imaging, and the Internet to improve access to

care for patients in remote settings. Through collaborative hygienists in remote areas, patients have improved access to preventive dental care. Through teleconsultation with specialists in larger communities, a dentist in a nearby community can provide access to specialty care for their patients more easily. Teledentistry allows the specialist located many miles away to make a diagnosis and recommend treatment options and/or referral for patients who otherwise would find it difficult to see them. Future advances in technology will enable teledentistry to be used in many more ways, including advances seen in medicine such as clinical decision support, quality and safety assessment, consumer home use, medication e-prescribing, and simulation training.

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