

Applications of teledentistry: A literature review and update

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Abstract

Teledentistry is a combination of telecommunications and dentistry involving the exchange of clinical information and images over remote distances for dental consultation and treatment planning. Teledentistry has the ability to improve access to oral healthcare, improve the delivery of oral healthcare, and lower its costs. It also has the potential to eliminate the disparities in oral health care between rural and urban communities. This article reviews the origin, rationale, scope, basis, and requirements for teledentistry, along with the current evidence that exists in the literature. This article also reviews the ethical and legal issues related to the practice of teledentistry and the future of this alternative and innovative method of delivering dental care.

Key words: *Information technology, internet, teleconsultation, teledentistry, telediagnosis, telemedicine*

INTRODUCTION

“Telemedicine” is the use of information-based technologies and communications systems to deliver healthcare across geographic distances.^[1] It uses electronic information to communicate technologies to provide and support healthcare when distances separate the participants.^[2] Telemedicine is part of a wider process or chain of care. It can improve this chain and thus enhance the quality and efficiency of health care.^[3] Telemedicine is being used today in academic medical centers, community hospitals, managed-care companies, rural hospitals, and is also being used internationally to link providers in developing countries to hospitals in developed countries. Advances in digital

communication, telecommunication, and the Internet introduce an unprecedented opportunity to remote access to medical care.^[4]

The field of dentistry has seen extensive technologic innovations in recent years. Advances have been made in the use of computers, telecommunication technology, digital diagnostic imaging services, devices and software for analysis and follow-up.^[5] Using advanced information technology, the science of dentistry, today, has crossed much longer distances than it was ever able to.^[6] New information technology has not only improved the quality of management of dental patients, but also has made possible their partial or complete management at distances of thousands of kilometers away from healthcare centers or qualified dentists. The entire process of networking, sharing digital information, distant consultations, workup, and analysis is dealt with by a segment of the science of telemedicine concerned with dentistry known as “Teledentistry”.^[7]

DEFINITIONS

To some, teledentistry means searching the Web for

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information that might help a patient. To others, it is partaking of online continuing education courses. In reality, these two activities are actually Web surfing and distance learning.^[5] Teledentistry, on the other hand, is a combination of telecommunications and dentistry, involving the exchange of clinical information and images over remote distances for dental consultation and treatment planning.^[8] The term “Teledentistry” was first used in 1997, when Cook defined it as “... the practice of using video-conferencing technologies to diagnose and provide advice about treatment over a distance.”^[9]

ORIGIN

The initial concept of teledentistry developed as part of the blueprint for dental informatics, which was drafted at a 1989 conference funded by the Westinghouse Electronics Systems Group in Baltimore. Focus was on a discussion of how to apply dental informatics in dental practice to directly affect the delivery of oral healthcare.^[10] The birth of teledentistry as a subspecialist field of telemedicine can be linked to 1994 and a military project of the United States Army (U.S. Army’s Total Dental Access Project), aiming to improve patient care, dental education, and effectuation of the communication between dentists and dental laboratories. This military project demonstrated that teledentistry reduced total patient care costs, extending dental care to distant and rural areas and offering complete information required for deeper analyses.^[7] As technology has advanced, new opportunities for teledentistry have been created. Technologies currently available are beginning to change the dynamics of dental care delivery. Teledentistry will offer new opportunities to improve the level of patient care and reshape current business models.^[11]

METHODS OF TELECONSULTATION

Teleconsultation through teledentistry can take place in either of the following ways – “Real-Time Consultation” and “Store-and Forward Method”.^[12] Real-Time Consultation involves a videoconference in which dental professionals and their patients, at different locations, may see, hear, and communicate with one another [Figure 1].^[6] Store-and-Forward Method involves the exchange of clinical information and static images collected and stored by the dental practitioner, who forwards them for consultation and treatment planning [Figure 2].^[13] The patient is not present during the “consultation”.^[14] Dentists

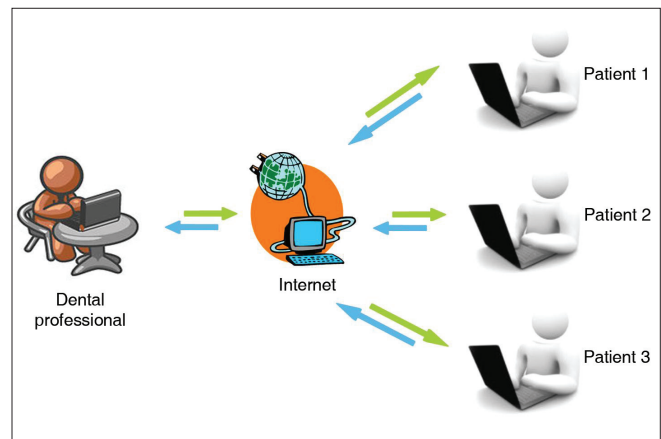


Figure 1: Real-time consultation

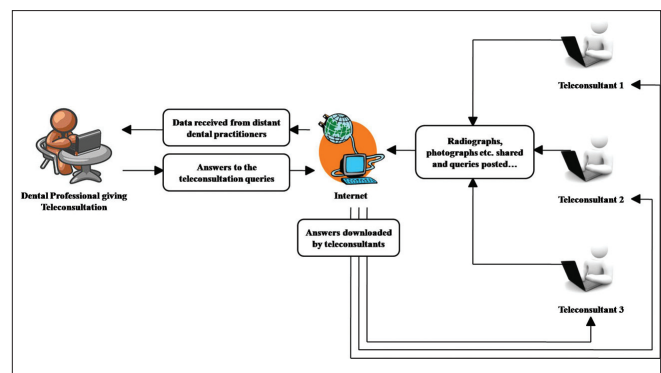


Figure 2: Store-and-forward method

can share patient information, radiographs, raphical representations of periodontal and hard tissues, therapies applied, lab results, tests, remarks, photographs, and other information transportable through multiple providers. This data sharing can be of extreme importance for patients, especially those in need of specialist consultation.^[7] A third method has also been described, known as “Remote Monitoring Method”, in which patients are monitored at a distance and can either be hospital-based or home-based.^[15] A “Near-Real-Time” consultation has also been mentioned in the literature, which involves low resolution, low frame rate product that looks like jittery television.^[11]

SCOPE

Teledentistry has the ability to improve access to oral health care, improve the delivery of oral healthcare and lower its costs.^[14] It also has the potential to eliminate the disparities in oral healthcare between rural and urban communities.^[12] Teledentistry may turn out to be the cheapest, as well as the fastest, way to bridge the rural-urban health divide. Taking into account the huge strides in the field of information and communication

technology, teledentistry can help to bring specialized healthcare to the remotest corners of the world.^[16] Lienert N *et al.* found that telemedical services were helpful for cases related to dental trauma in a Swiss telemedical center and provided valuable support where a specialty dentist was not available.^[17] Snow MD *et al.* noticed that teledentistry permitted distant, cost-effective specialist dental consultations for rural Australians.^[18]

If the projections on the shortages of dentists in the next decade come to pass, teledentistry will be important not only for rural areas but also for our urban and suburban populations.^[19] Inter-professional communications will improve dentistry's integration into the larger healthcare delivery system.^[6] The use of teledentistry for specialist consultations, diagnosis, treatment planning and coordination, and continuity of care will provide aspects of decision support and facilitate a sharing of the contextual knowledge of the patient among dentists.^[20] Second opinions, pre-authorization and other insurance requirements will be met almost instantaneously online, with the use of real images of dental problems rather than tooth charts and written descriptions.^[6] Teledentistry will also provide an opportunity to supplement traditional teaching methods in dental education, and provide new opportunities for dental students and dentists.^[21]

BASIS OF TELEDENTISTRY: THE INTERNET

Internet is the basis of modern systems of teledentistry, being up-to-date and fast, and able to transport large amounts of data. All new systems of teledentistry are Internet-based, as well as all kinds of distant consultation.^[7] Changes within the past decade in the speed and method of data transfer have prompted clinicians and information technology experts to re-evaluate teledentistry as a highly valuable healthcare tool.^[10] A study conducted by Nainar SMH *et al.* showed that most pediatric dental practices in Connecticut were connected to the Internet.^[22] Leao JC and Porter SR suggested telediagnosis of common orofacial diseases via the Internet a feasible prospect.^[23] An Internet-based telemedicine program (Baby CareLink) significantly improved patient family satisfaction and lowered the costs associated with hospital to hospital transfer after neonatal intensive care unit (NICU) stay.^[24] Thus, the deployment of the Internet and broadband high-speed connections remain the cornerstones of modern teledentistry, and have helped teledentistry enter a new era.^[10]

Information and communication technologies used in conjunction with Internet have become a central part of academic life in colleges and campuses. Internet-based teledentistry education enables students to choose themselves the place, time, and mode of learning.^[7] In continued professional dental education, modern Internet systems also offer on-line video-conferencing, broadcasting operations and treatments, and on-line training courses.^[25] Correa L *et al.* evaluated a Web-based practical course on oral surgery principles and concluded that Web-based distance learning courses with practical modules must be considered as a special type of educational modality fetching satisfactory results.^[26] Ignatius E *et al.* investigated teledentistry in dental specialist education in Finland and suggested that videoconferencing is suitable for long distance learning in dentistry.^[27] "TME 3/347", a Web-based teledentistry consultation system developed for the US Department of Defence dental clinics, showed that videoconferencing, Web and Internet based technologies can be used to implement a user-friendly teledentistry solution.^[28]

REQUIREMENTS

For most dental applications, store-and-forward technology provides excellent results without excessive costs for equipment or connectivity. A typical store-and-forward teledentistry system consists of – a computer with substantial hard drive memory, adequate RAM, and a speedy processor; an intraoral video camera and a digital camera for the capture of pictures; a modem and an Internet connection. A fax machine, a scanner, and a printer may also be required in some cases.^[6,11,13] To enable live videoconferencing, one might employ a widely available standalone IP/ISDN videoconferencing solution, or install a PCI codec board into the system. If a live group session is desired, a multipoint control unit that bridges three or more parties is required. The codec must be able to accommodate audio and visual functions.^[29]

CURRENT EVIDENCE FOR TELEDENTISTRY

Role in oral medicine and diagnosis

Bradley M *et al.* successfully proved the use of teledentistry in oral medicine in a community dental service in Belfast, N. Ireland, using a prototype teledentistry system.^[30] Torres-Pereira C *et al.* suggested that distant diagnosis is an effective alternative in the diagnosis of oral lesions using transmission of digital images by email.^[31] Summerfelt FF reported a teledentistry-assisted, affiliated practice dental hygiene

model developed by the Northern Arizona University Dental Hygiene Department, that allowed dental hygienists to provide oral healthcare to underserved populations by digitally linking up with a distant oral health team.^[32]

Role in oral and maxillofacial surgery

Duka M *et al.* showed that diagnostic assessment of the clinical diagnosis of impacted or semi-impacted third molars assisted by the telemedicine approach was equal to the real-time assessment of clinical diagnosis.^[33] According to Rollert MK *et al.*, telemedicine consultations, in adequately assessing patients for dentoalveolar surgery with general anesthesia and nasotracheal intubation, are as reliable as those conducted by traditional methods and that telecommunication is an efficient and cost-effective mechanism to provide pre-operative evaluation in situations in which patient transport is difficult or costly.^[34] Brickley M stated that there is a need and demand for change in the referral system for oral surgery specialist care. Telemedicine could conceivably be one way to improve access to specialist oral surgery care.^[35] Aziz SR and Ziccardi VB stated that Smartphones provide fast and clear access to electronically mailed digital images and allows the oral/maxillofacial surgeon free mobility, not restricted by the constraints of a desktop personal computer. This in turn allows for improved efficiency of the specialty consultation and improved triaging, ultimately providing improved care to the maxillofacial patient.^[36]

Role in endodontics

Brullmann D *et al.* reported that remote dentists can identify root canal orifices based on images of endodontically accessed teeth.^[37] Zivkovic D *et al.* demonstrated that teledentistry based on the Internet as a telecommunication medium can be successfully utilized in the diagnosis of periapical lesions of the front teeth, reducing the costs associated with distant visits and making urgent help available.^[38] Baker WP 3rd *et al.* showed that no statistical difference existed between the ability of evaluators to identify periapical bone lesions using conventional radiographs on a viewbox and their ability to interpret the same images transmitted on a monitor screen by a video teleconferencing system.^[39]

Role in orthodontics

According to Berndt F *et al.*, interceptive orthodontic treatments provided by sufficiently prepared general dentists and supervised remotely by orthodontic specialists through teledentistry are a viable approach to

reducing the severity of malocclusions in disadvantaged children when referral to an orthodontist is not feasible.^[40] A study by Stephens CD and Cook J shows that a majority of UK orthodontic consultants support the concept of using teledentistry to make their advice more accessible to dentists and patients.^[41] A survey by Mandall NA *et al.* revealed that general dental practitioners generally supported a teledentistry system to screen new patient orthodontic referrals.^[42] Stephens CD *et al.* studied the effect of teledentistry advice on outcome of orthodontic treatment provided by general dental practitioners showed that “TeleDent SW” enabled them to offer a better service for their patients and use specialist services more appropriately.^[43] Cook J *et al.* tested an online teledentistry service and showed that it helped to reduce the high level of inappropriate orthodontic referrals to consultants and provided general dental practitioners with quick access to advice that would enable them to tackle a wider range of cases themselves.^[44] A survey by Bradley SM *et al.* showed that almost half of the general dental practitioners in West Yorkshire, who responded, had a positive attitude towards the benefits of using teledentistry to obtain advice from orthodontic consultants.^[45] Favero L *et al.* stated that telecommunications applied to dentistry is particularly useful in the orthodontic field, as minor emergencies (rubber ligature displacement, discomfort due to the appliance, irritation of cheeks) can be solved easily at home, reassuring patient and parents on one hand, and limiting visits to the dental office to cases of real need.^[46] Mandall NA carried out a trial to assess the validity of a teledentistry system for screening orthodontic referrals. Patients were referred through a “store and forward” teledentistry link and were later evaluated clinically, to assess whether the same decision to accept the referral was made. It was seen that clinician agreement for screening and accepting orthodontic referrals based on clinical photographs was comparable to that reported for clinical decision making.^[47]

Role in prosthodontics

Ignatius E *et al.* investigated the use of videoconferencing for diagnosis and treatment planning for patients requiring prosthetic or oral rehabilitation treatment and stated that video-consultation in dentistry has the potential to increase the total number of dental specialist services in sparsely populated areas.^[48]

Role in periodontics

The Web-based teledentistry consultation system developed for the US Department of Defence

dental clinics showed that referrals to oral surgery, prosthodontics and periodontics had the highest number of consults.^[49] Fifteen patients underwent periodontal surgery at Fort Gordon, Georgia, and a week later, their sutures were removed at a location 150 miles away under the tele-supervision of the Periodontist. Only 1 patient made the return-trip for a follow-up procedure.

Role in pediatric and preventive dentistry

Kopycka-Kedzierawski DT and Billings RJ showed that teledentistry is as good as visual/tactile examinations for dental caries screening in young children.^[50] Kopycka-Kedzierawski DT *et al.* suggested that teledentistry offers a potentially efficient means of screening high-risk preschool children for signs of early childhood caries.^[51] They successfully demonstrated a teledentistry project established in inner-city child-care centers in Rochester, NY.^[52] Amavel R *et al.* stated that remote diagnosis of children dental problems based on non-invasive photographs constitute a valid resource.^[53] Kopycka-Kedzierawski DT *et al.* demonstrated 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.^[54]

ETHICAL AND LEGAL ISSUES

Concerns about the confidentiality of dental information arise from the transfer of medical histories and records as well as from general security issues of electronic information stored in computers.^[55] The practitioners of teledentistry should take utmost care to ensure that patient privacy is not compromised by unauthorized entities. However, patients should be made aware that their information is to be transmitted electronically and the possibility exists that the information will be intercepted, despite maximum efforts to maintain security.^[13] Concerns also may arise about the proper method of informing patients of the potential transmission of their data. Informed consent in teledentistry should cover everything that exists in a standard, traditional consent form. The patient should be informed of the inherent risk of improper diagnosis and/or treatment due to failure of the technology involved.^[14]

In teledentistry practice, medicolegal and copyright issues also have to be considered.^[56] These problems arise primarily due to a lack of well-defined standards.^[14] Currently, there is no method to ensure

quality, safety, efficiency, or effectiveness of information or its exchange. There are privacy and security issues as well as remuneration, fiscal and taxation issues associated with electronic commerce. Many of the legal issues, such as licensure, jurisdiction, and malpractice, have not yet been definitively decided by legislative or judicial branches of various governments.^[57] In 2000, 20 states in the US enforced restrictive licensure laws requiring teledentistry practitioners to obtain full licenses to practice across state lines.^[14] In spite of this, information on teledentistry licensure does not appear to be readily available today.^[13]

DISCUSSION

Teledentistry is 'not' a new specialty. It is, in reality, an alternative method to deliver the existing dental services. The utility of teledentistry in distant, remote areas cannot be emphasized enough. Its application is of utmost importance and great value in rural and urban areas where there is unavailability of specialist consultation. In a feasibility study undertaken by the Chin-Shan Group Health Center and National Taiwan University Hospital in 2000, a single resident, equipped with an intraoral camera, a digital radiographic system, and a software application to transfer all images to the hospital, was sent to the Chin-Shan Township of 17,000 people. This pilot project demonstrated the effectiveness of teledentistry in providing dental care to individuals living in a remote area and the viability of remote specialty consultations.^[58] In 2006, the Eastman Department of Dentistry at the University of Rochester employed a teledentistry project in six inner-city elementary schools and seven child-care centers and successfully screened 173 children revealing that almost 40% of the children aged 12-48 months had active dental caries.^[52] In Northern Ireland in 2010, a prototype teledentistry system was set up by the Community Dental Service of the Homefirst Legacy Trust in partnership with the Oral Medicine Department at the School of Dentistry, Belfast Trust and the feasibility of teledentistry as an alternative approach to the management of oral medicine referrals was positively established.^[30]

Teledentistry is a new facet of overall patient care that is rapidly increasing in popularity and value.^[11] It will produce wonderful advantages for the patients of a primary care doctor who partakes of the vast expertise available through teleconsultation.^[5] Exchange of information will lead to improved patient care, and the ability to consult more efficiently with colleagues will lead to greater understanding of the treatment objectives

and better treatment outcomes.^[59] Efficient utilization of teledentistry will bring fruitful development of Family Dentistry in the future as family dentists can serve as gatekeepers for specialist services, coordinating the dental treatment provided by other dental specialties.^[21]

Though Internet-based Teledentistry has taken precedence over other ways of communication, potential shortcomings exist, like – necessity for appropriate training, pressure for an instant response, message-misunderstanding, privacy concerns and possibility to overlook/neglect the messages.^[7] It is mandatory that practitioners choosing to include teledentistry as part of their practices should educate themselves as to the legal, technological, and ethical issues that are a part of this new practice medium.^[14] Dentists must take initiative by becoming comfortable in the electronic world. They must begin by understanding not only how their practices will be affected by the digital transformation of healthcare, but also how they and their patients can benefit from appropriate development of teledentistry.^[60] Implementation of teledentistry in professional dental education is an efficient and practical way of building up teledental skills. Cooper BR and Engeswick LM examined dental hygiene students' knowledge, attitudes, and confidence levels before and after completion of a course on teledentistry and saw that the students' attitudes were positively changed in their knowledge of the effectiveness of teledentistry in identifying dental needs in underserved areas.^[61] In addition, more is required of the instructors for teledentistry education courses because they need to have both teaching experience and computer knowledge.^[10]

Cost of the telecommunication equipment has also been a matter of concern. A systematic review of cost effectiveness studies of telemedicine interventions by Whitten PS *et al.* showed that there is no good evidence for telemedicine as a cost effective means of delivering healthcare.^[62] Scuffham PA and Steed M conducted a 12-month trial of teledentistry concluded that there were no cost-savings from teledentistry. However, they estimated that the cost-effectiveness of teledentistry would improve with greater familiarity and use of equipment.^[63] It has been a decade now since these cost-effectiveness studies have been published. Now-a-days, almost all dental practice set-ups have intra-oral cameras, digital cameras and computers with Internet access, which automatically cater to teledental solutions. As technology has advanced, changes in the size, features, and costs of various technological components

have reduced the cost of teledental consultations.^[11]

Another important aspect that requires light is the payment of the healthcare professionals who provide teleconsultation. For telemedical consultation, it might be reasonable to charge the same rate as an ordinary face-to-face consultation.^[64] However, reimbursement for teleconsultation has been a constant issue in the recent years.^[65] The National Rural Health Research and Policy Analysis Center has recommended reimbursement of care provided by teleconsultants, eliminating separate billing procedures for telemedicine, increasing reimbursement for the originating telemedicine sites, and providing reimbursement for store-and-forward applications.^[66] In the US, there are several major payers for telemedicine reimbursement including Medicare, Federally Qualified Health Centers, Medicaid (Medi-Cal), Healthy Families Program, California Children's Services, and County Medical Services Program. Apart from these federal and state programs, commercial or private insurances are also available, for example, Blue Cross of California.^[67] These facts apart, reimbursement for teledentistry has not yet been considered. What still remains a question is "who is going to pay for the teledental consultations"? Majority of the studies done on teledental applications have been covered by grant money and although the fate of these programs after the funding stopped is unknown, it is probable that the studies were terminated due to lack of financial support. None of the programs that reimburse telemedical consultations have included teledental reimbursement in their policies as yet. A solution to this issue has to be found immediately. Reimbursement for teledentistry in the same was telemedicine is reimbursed is a definite option. Other alternatives should be looked into and it has to be ensured that all teledental consultants are properly compensated for their virtual visits.

CONCLUSION

With all the technological developments taking place in the field of teledentistry, practitioners may eventually link up to virtual dental health clinics and an entirely new era of dentistry can be created. The future might also see distant telemedical control of robotized instruments in situations with long-term unavailability of dental care, e.g., during space flights, on transoceanic ships, and in various rural areas. The results achieved so far are very encouraging, setting the road signs for future investigations. However, a number of things have to be addressed before teledentistry can rise to its peak. Further studies involving greater number of participants will be required to validate the various aspects of teledental applications.

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