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CASE STUDY

TELEDENTISTRY - A NEW ERA, EVOLUTION AND ADVANCEMENT IN DENTISTRY

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ABSTRACT

Teledentistry is the use of telemedicine in dentistry it is use of information technology and telecommunications for dental care, consultation with referral, education, and patient education. Telemedicine has been used as an effective method to improve the quality of care and reduce the cost of health care. Teledentistry is beginning of new era in the field of dentistry that unites telecommunication, digital imaging, and the Internet to join health professionals in rural and distant areas. New information technology not only improve the quality of management of dental patients, but also makes possible their partial or complete management at distances of thousands of kilometres away from health care centres or qualified dentists. The article highlights history, methods, types, uses of teledentistry along with future perspectives.

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INTRODUCTION

Teledentistry is a new evolution in the field of dentistry that combines telecommunication technology and dental care. It gives new opportunities for education and delivery of care that offer much potential and challenges. Due to the advancement in technology, teledentistry possesses the potential to fundamentally change the current practice and the face of care (Dils, 2004). Today dental practice is equipped with computerized patient registry, electronic invoicing, digital radiography, intraoral and digital cameras, 3D computerized systems for prosthetic reconstruction, 3D cone beam computerized tomography imaging, measurements and navigation in oral and maxillofacial surgery. Dentists seem to have innate love for new technologies.We are "Gadgeteers" and we usually respond with great enthusiasm to new developments (Clark, 2000). We are seeing a decline in the dental disease among young patients, we are also facing an aging population people are living longer and wanting to maintain their dentitions throughout their lives new technologies challenge the current paradigms of dental practice and will lead significant shiftin future treatment modes (Bhambal, 2010).

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History of Teledentistry

The United States military formally launched a coordinatedtelemedicine program in 1994. The ultimate purpose of this program is to investigate clinically relevant applications ofthis rapidly emerging technology. The military efforts intelemedicine are part of a broad attempt to "re-engineer"the delivery of health services.One of the military telemedicine efforts was to start a teledentistry project. The Total Dental Access (TDA) is atri-service teledentistry project (1994) aiming to increase patient access to quality dental care and establishing a costeffective telemedicine system. The Total Dental Accessproject focuses on three areas of dentistry (Mihailovic, 2011).

Patient care: In some of the remote clinics, a patient musttravel hundreds of miles to receive speciality care. Oftenpre-and post-operative visits take only a few minutes ofactual appointment time but require hours of travel by thepatient. With the implementation of teledentistry, there is apotential of savings in cost and travel time required by thepatient. Referral to specialists, consultations and laboratory communications are some of the clinical areas where Teledentistry could improve the patient care.

Continuing dental education: The lectures could bebroadcasted to any clinic where continuing dental educationis difficult to obtain with the help of videoteleconferencing equipment.

Dentist Laboratory Communications: Casessubmitted to the dental laboratories havecomplications or esthetic variations that, occasionally, require direct communicationbetween the dentist and thelaboratory technician. We can easily send colored images of the patient'steeth to discuss and prevent making improperly constructed appliances, thereby saving time and money.

Methods of Transfering Information

- Image File Transfer via Modem.
- File Image Transfer via Satellite.
- ISDN-based Teledentistry System
- POTS-based Teledentistry System
- Web-based Teledentistry Systems

Step 1: **Image File Transfer via Modem**

The US Army conducted the first study of teledentistry at Fort Gordon, Georgia in July 1994.In this study a dental image management system wasused in conjunction with an Intra-oral camera to capture color images of a patient's mouth. These images were then transmitted over a 9600 baud modem from the dental clinic in Fort McPherson, Georgia to Fort Gordon, a distance of 120 miles. Fifteen periodontal patients were referred to Fort Gordon for surgery. One week after their surgery,each patient reported to Fort McPherson for sutureremoval and intra-oral imaging. At the time of sutureremoval, color still images were obtained of thesurgical sites and these images were transmitted Fort Gordon for examination by the periodontist whoperformed the surgery (Vandre, 1995).

Step 2: **File Image Transfer via Satellite**

The second study was performed in Haiti in 1995. Inthis Study a CLI video teleconferencing system wasused over International Maritime Satellite(INMARSAT) allowing the deployed dentists to talkface to face with specialists at Walter Reed Army Medical Center in Washington. In addition, a highresolutionstill camera was used to capture color stillimages. The images were then transmitted with thecolor still images to Walter Reed where thespecialists reviewed them (Vandre, 1995).

Step 3: ISDN-based Teledentistry System

For this project the Army posts of the southeast Dental Service Support Area (DSSA) were networked using desktop video teleconferencing Equipment (PictureTel 50) and ISDN lines at 128 Kbps data rates, an intra-oral camera and a document camera. This equipment allows live video consultingas well as capability to send still images.White-boarding is a feature of this system, which allows users to do annotation on an image.In 1996, the US Department of Defense established a medical network in Bosnia that connected Army fielddentists with dentists at five regional military medical centres in the United States (Washington, Texas, California, District of Columbia, and Hawaii). The Telemedicine segment of this project (Primetime III) utilized communication satellites to allow military physicians to consult one another using real-timevoice and video. Using commercially availabletechnology, dentists transmitted radiographs, colorimages, and full motion videos to remote fieldhospitals for diagnostic support. They obtained forward delivery of laboratory and radiologicalresults, prescription support, utilized digitizedmedical logistics support, online clinical information, email, and medical command and control situational awareness technologies.

Step 4: POTS-based Teledentistry System

In early 1997, a POTS-based teledentistry networkwas tested and implemented in Germany, Italy, Belgium, England, Spain and Portugal. This systemhas been mainly deployed to smaller dental clinics in Europe, which did not have Internet access at thetime. The POTS-based network has been established for the US Army, Navy and Air Force Dental clinicsat over 52 sites in Europe and 16 sites in the United States. The POTS-based systems consist of a desktopcomputer, a 28.8 Kbps modem, software andhardware (Sharevision PCS3000), Intra-oral cameraand a document camera (Vandre, 1995).

Step 5: Web-based Teledentistry Systems

Internet provides an appealing medium for the communication of health related information due to its ease of use and growing popularity. The Web-based teledentistry system which has been deployed since October 1997 consists of a laptop, a digital camera, a Web browser and requires Internet access. Since most of the dental clinics in Europe now have a local Area Network (LAN) and access to Internet through the medical hospitals, this system is being used in over 50 tri-service dental clinics in Europe. A Web-based clinical database has been developed for storing the consults. This system uses MS SQL Server 7.0 for storing the consults as the database server and MS Internet Information Server 4.0 as the Web server. The Referring dentist logs into a secure server using a Web browser. He chooses a specialty (orthodontics, oral medicine, oral and maxillofacial surgery, endodontics, oral pathology, periodontics, prosthodontics or pediatric dentistry). He then sends the patient demographics, complaint, images and radiographs to the specialist of his choice. The data gets sent to the database and an electronic mail notifies the specialist of the pending consult, which he will access via the Internet. The specialist reviews the consult and writes his diagnosis and treatment. A plugin developed in Visual C++ enables him to do image manipulations, such as contrast and brightness changes of the radiographs within the Web browser. He then types the diagnosis and suggested treatment. The completed consult is now stored on the database server. The referring dentist receives an email indicating that his consult has been answered (Vandre, 1995).

Methods of Teleconsultation in Teledentistry

Two way interactive /Real time consultation

Real-Time Consultation involves a videoconference in which dental professionals and their patients, at different locations, may see, hear, and communicate with one another.

Store and Forward

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

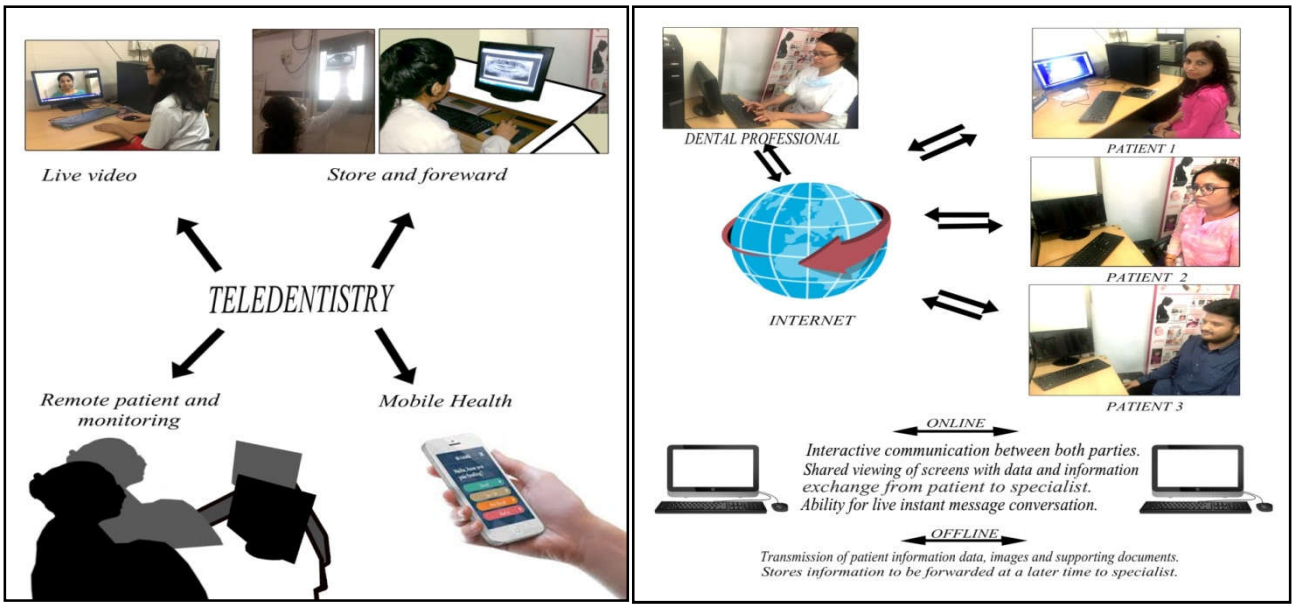

Figure 1. Methods of Teleconsultation: Real time consultation and Store & Forward

Applications in Dental Education

Teledentistry and its application in dental education: Teledentistry has two branches: self-learning and interactive conferencing. Self-instruction educational system contains information that has been generated and stored prior to user's access (Kirshner, 2003). The advantage here is that the user has the control control of pace while learning with multiple reviewing facility. Interactive video-conferencing may be conducted via POTS (plain old telephone service), satellite, ISDN, Internet or Intranet. it includes both a live interactive sessionwith a proper camera set up where the patient's information (such as the patient's medical history, radiographs, etc) can be transmitted.immediate feedback is the biggest advantage of this type of education system.

Teledentistry and its use in rural areas: In rural areas, the lack of comprehensive health care is a problem due to less availability of specialists.Teledentistry can increase the accessibility of the specialists to the rural and underserved communities for their dental needs, besides decreasing the time and the cost which are associated with the speciality consultations . Altering the service delivery method may increase the feasibility of a rural practice. Seclusion from peers, specialists, and continuing education opportunities are the drawbacks of a rural practice. Financial obligations can be met by providing dental care in a paid arrangement while learning to build the experienced efficiencies in care delivery without incurring additional debt (Snow, 2000).

Teledentistry and its role in postgraduate education and dental practice: There lies a good tool in teledentistry for educating postgraduate students as well as providing them with latest updates. In interactive video-conferencing, the patient information can be discussed and evaluated first (with or without the patient's presence). This enhances the students' enthusiasm and provides new learningopputunities tothem as well as practicing dentists (Liu, 2006).

The role of teledentistry in schools and child care centres: Schools and child care centres ensure the optimum oral health through screening for dental problems before these become emergencies.

Helping children in managing chronic illnesses. Connecting children and their families to the needed health and social services, and Providing urgent care. Paediatric dentists at the University of Rochester use the photographs of toddlers to identify those with early childhood dental caries. A study of the program found that nearly 40 percent of 162 toddlers suffered from tooth decay. The early detection of such decay can prevent the child from painful and financial trauma, visits to the emergency treatment room, and ultimately, extractions of the teeth (Kirshner, 2003).

Application in Dentistry

Application in oral and maxillofacial Surgery

Improved diagnosis, situational analysis and planning of appropriate treatment modalities have been provided by the use of new technologies. For instance, Technologic development has made it possible to observe, inspect and diagnose the patient needing implant placement in one part of the world, and in the other part make a digital project of complete implant and prosthetic construction for navigational technique of dental implantation. One of the first cases was scientifically presented by the Karl Landsteiner Institute for Biotelematics, Vienna, consisting of a specially devised telenavigation server and telenavigation clients. Generally, the procedure of tele implantologic consultation is as follows: at the site of surgical dental implantation, it is first necessary to obtain CBCT image and 3D computerized jaw reconstruction. DICOM files are then transferred to the main server for storage, enabling multiple downloading of the files for review or intervention planning. Dentists, distant teleconsultants, then download the files, perform the requested actions such as software planning of the position, size, and shape of dental implants. If necessary, based on the digital placement scheme, a template for the implantation process is made, leading surgical drill in the jaw area, and navigation markers are positioned, enabling intraoperative navigation of surgical instruments during surgery itself. At the end, teleconsultants post the amended files to the server, and operators are then ready to begin the process of dental implantation.

Figure 2. Teledentistry approach for planning of dental implantation

Duka*et al*., conducted a study to investigate practical usability of telemedicine approaches in everyday management of oral surgery patients in terms of reliability of established diagnosis and indications for oral surgery treatment of the third molars (Duka, 2009).

Figure 3. Teledentistry approach for diagnosis and indications for third molars

They summarized that the 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. The practice of telemedicine was accurate, effective, and avoided unnecessary visits to the hospital and shortened waiting intervals. Aziz and Ziccardi summarized that the use of Smartphone telemedicine was an efficient and effective way for remote specialist consultation and recommended its consideration by the oral and maxillofacial surgeon. The literary works supports teledentistry could be effectively used in offering specialist services in oral surgery to the patients in far locations (Aziz, 2009).

Application in orthodontics

Clinical orthodontics, requiring a distant assistance, on a daily basis, forwarded the most in use of computerized technology. An orthodontic specialist takes impressions in hydrocolloid alginate and bite impression using polyvinyl siloxane, wax, or compatible materials. The impressions and bite are then sent to the OrthoCAD™ company by post. There, casts are made from the impressions, being after that scanned with special methods of 3D digitization. Upper and lower jaw models are articulated using the bite impression. Few days after being contacted, OrthoCAD™ uploads on its Internet servers the electronic file containing digital study model. The orthodontist is informed, and he downloads the file from the Internet and analyzes it with special 2D and 3D orthodontic softwares. Such a teleorthodontic system offers numerous benefits in the practice and markedly reduces processing and model storage costs. An orthodontist is able to offer appropriate expert support if rubber bands fall off the braces, in cases of discomfort wearing braces, and in assessment of the solution if irritations occur, without the need for patient visits to the clinic.

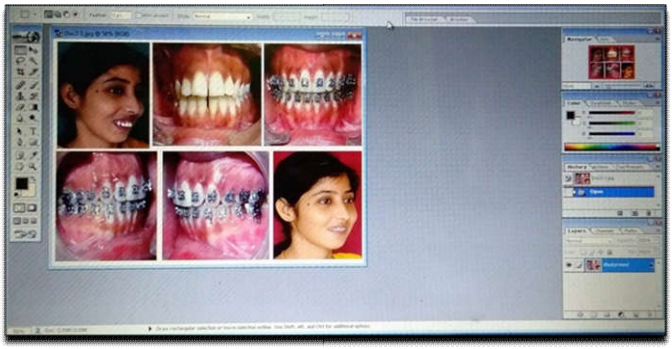

Figure 4. Teledentistry approach for providing interceptive orthodontic services

Berndt *et al*, assessed the feasibility of a general dental practitioner providing interceptive orthodontic services to disadvantaged children with real-time supervision from an orthodontist using teledentistry. The study concluded that interceptive orthodontic treatments provided by sufficiently prepared general dentists and supervised remotely by orthodontic specialists through teledentistry were a viable approach in reducing the severity of malocclusions in disadvantaged children when referral to an orthodontist was not feasible (Berndt, 2008).

Application in conservative dentistry and endodontics

Any faults in differential diagnosis and prognosis of treatment of periapical lesions can be the source of further complications along with consumption of time and money, sometimes which may be the cause of complete revisions of prosthetic restorations based on poorly treated teeth. Zivkovic et al. have practically demonstrated that the diagnosis of periapical lesions with the help teledentistry methods and Internet can be assessed adequately on the basis of which a necessary plan can be devised for proper endodontic or oral surgical approach required for these lesions. Teledentistry acts as a medium for communication at distant places enabling its use worldwide, thereby reducing the costs of management and ease of availability of urgent help to all patients (Zivkovic, 2010). Digital information is created for each of the teeth of interest: sequence of digital extraoral photographs (frontal and bilateral), sequence of digital intraoral photographs (vestibular portion of the alveolar ridge in the area at the level of tooth root, palatal/lingual portion of the alveolar ridge of the target tooth, and dental crown), retroalveolar dental digital x-ray,

anamnestic information in the format of text. Baker *et al 2000*, compared the interpretation of conventional radiographs transmitted by a video teleconferencing system to conventional view box interpretation for both artificial and *in vivo* periapical bone lesions (Baker, 2002).

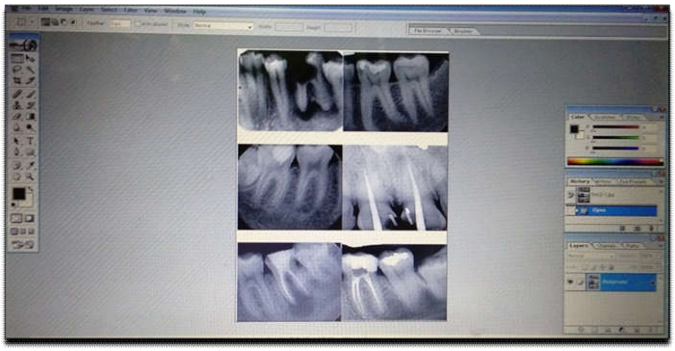

Figure 5. Teledentistry approach for diagnosis of periapical lesions

Role in Pediatric Dentistry

Mass disease of caries with etiologically insufficiently known nature can be suppressed by early detection of caries and its prevention. Amável et al. have demonstrated in real conditions that dental problems and dental treatment preparation have been made easy by on non-invasive imaging for diagnosis of distant pediatric dental patients (Amavel, 2009). Kopycka-Kedzierawski et al. have successfully studied the prevalence of dental caries in children using the telecommunication technology and dental photographs were taken with intraoral cameras and web-based storage of images (Kopycka-Kedzierawski, 2008). These authors, in their study have evaluated a telemedical system of distant systematic dental check-up in children, using the transmission of digital images so as to get a complete insight into the status of teeth of these children, with special emphasis on early dental caries. Kedzierawski and Billings assessed dental caries prevalence and dental care utilization in preschool children enrolled in urban childcare centres in comparative efficient study (Kopycka-Kedzierawski, 2007).

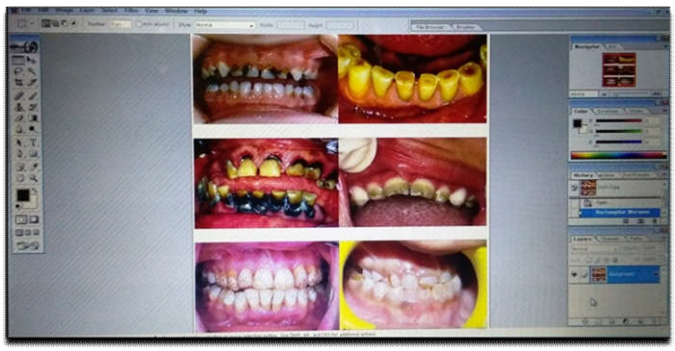

Figure 6. Teledentistry approach for diagnosis of dental caries and staining

The authors summarized that teledentistry offered potentially efficient means for screening of high-risk preschool children for signs of early childhood caries which was as good as visual/tactile examinations for dental caries screening in young children. The study showed that the use of intraoral camera was feasible and cost-effective alternative to a visual oral examination for caries evaluation, especially early childhood caries, in preschool children who visits childcare centers. Digital images obtained with high resolution intraoral cameras is able to demonstrate initial caries stages or enamel and dentin pigmentations. The method of teledentistry has been demonstrated in providing dental screening in distant, rural, and other inaccessible areas and as an alternative in children afraid of dentists, thereby reducing their fear and anxiety compared to clinical examination in real time. These studies along with others demonstrate the efficiency of teledentistry in assessing the prevalence of dental caries and other disorders among children where a pediatric dentist's consultation may be obtained in a cost-effective manner.

Application in oral medicine and radio-diagnosis

Telemedicine with the help of high resolution images and a broad spectrum of colors (32-bit or more) provides consultation with the colleagues in inaccessible and rural areas between two or several experts at a time . Bradley *et al*, in a study proved that teledentistry can be used successfully to offer consultations oral medicine and radio-diagnosis in a community dental treatment, Northern Ireland (Bradley, 2010). Torres-Pereira et al. showed an effective distant access to oral lesions and benefits of use of e-mail services and a Store-And-Forward image system. Clinical and anamnestic data which is electronically photographed using a 50 mm macro lens and circular illumination system are stored in a textual file with minimal resolution of 600 dpi. The files are then appropriately renamed according to the patients' identification numbers so as to avoid confounding and indentity errors. These obtained images and clinical information is then analyzed by Specialist of oral medicine who make the diagnosis (usually one or two) and electronically return the results. The approach is such that it produces satisfactory results, which could be improved with comprehensive electronic patient history, containing the complete history of all present and past diseases, medications taken, diagnostic and therapeutic procedures, and recorded all other factors which could have influence on the status of currently assessed lesion. Teledentistry has reduced waiting periods and saved resources by offering these services at local levels with specialist consultation. Pereira *et al,* assessed the feasibility of distant diagnosis of oral diseases, using transmission of images through email (Torres-Pereira, 2008).

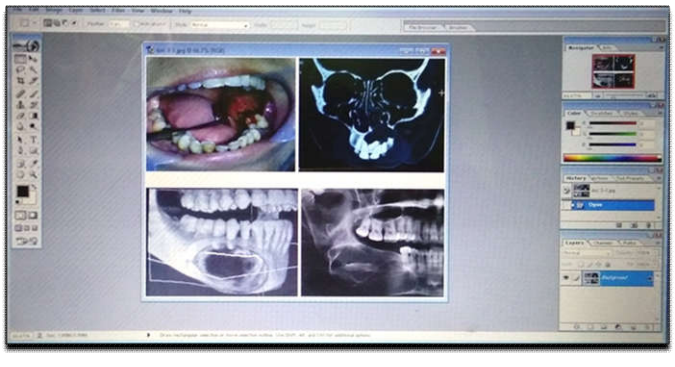

Figure 7. Teledentistry approach for diagnosis various oral pathological lesions

Oral lesions and conditions which are documented in teledentistry includes

1.Dental caries (initial and advanced)	8.Fibroepitelial polyps
2.Mucocele	9.Amalgam tattoos
3.Fibrous hyperplasia	10.Denture granuloma and keratosis
4.Leukoplakia	11.Orofacial granulomatosis
5.Candidiais	12.Sialosis
6.Ulceration	13.Apthous ulcer
7.Tongue lesions	14.Epidermoid carcinoma
	15.Pyogenic granuloma

Application in prosthodontics

CAD/CAM (computer-aided design and computer-aided manufacturing) systems are dominating in the processing of dental crowns, crowns and bridges, dental inlays and onlays over conventional hand modelling and casting of prosthetic reconstructions. The manufacturing of these dental structures involves 3D imaging using the active carrier principle, after tooth-carrier preparation with intraoral camera has been done. CAD projection of tooth restoration is then performed.the software is capable of automation of a large part of the job in aces of inlays and onlyas, however, if crowns are to be done, greater participation of the user (computer operator) is required.

Figure 8. CAD/CAM system

Ignatius et al, conducted a study to investigate the use of videoconferencing for diagnosis and treatment planning for patients requiring prosthetic or oral rehabilitation procedures [20]. The resulting project file is encrypted and sent by e-mail to a teleconsultant for model analysis, projection of the shape of restoration, of its height and interjaw relationships using a virtual articulator; the completed project is then encrypted and returned to the clinic, usually by e-mail . Telemedicine not only plays an important role in the CAD/CAM systems but also aids in examination of patients needing dental prosthesis and obtains general idea about choice of prosthesis and and gross cost.

Application in periodontics

Rocca*et al*, described the evolution of a teledentistry system within the U S department of defense (Rocca, 1999). Total dental access (TDA) was a teledentistry project within the Department of Defence that enabled referring dentists from the US Armed Forces to consult with specialists on the status of a patient. TDA concentrated on three areas of dentistry: continuing education, patient care, and dentist-laboratory communications. Increased patient access to quality dental care and a cost effective telemedicine system were two major goals of this project.

Figure 9. Teledentistry approach for diagnosis of gingival conditions and providing education and motivation

Steps in an internet-based teledentistry systems

- The referring dentist enters into a secure server.
- He picks a specialty (orthodontics, periodontics, prosthodontics, oral and maxillofacial surgery, oral medicine, endodontic, oral pathology, or paediatric dentistry) and then directs the patient demographics, complaints, radiographs and images, to the specialist of patient's choice.
- The data is then transferred to the database.
- An electronic mail informs the specialist of the pending consult, to route via the Internet.
- The specialist interprets and forms the diagnosis and treatment planning, storing the ended consult on the database server.
- The referring dentist gets an email indicating that his consult has been answered.
- An average of 40 consults per month were done via web-based teledentistry, according to the results. Extremely minimum cost, expandable to a wide range of locations and more detailed information for data analysis are some of the advantages of internet-based teledentistry.

Teledentistry in different countries

- University of Minnesota School of Dentistry – Increases acess to dental specialty care in rural areas via real-time videoconferencing technology.
- The Melbourne Dental School's Oral Cooperative Research Health Centre - Dental health care amongst aged and remote patients using the National Broadband Network.
- Arizona Department of Health Services, Office of Oral Health (00H) - Increase availability of the oral health workforce and accessibility of oral health services to underserved populations and underserved sreas in Arizona. Also increases access to dental care for underserved and at- risk populations
- University of Southern California's Mobile Dental Clinic and The Children's Hospital Los Angeles Teledentistry Project - Increases and enhances the

quality of oral health care provided to children living in remote rural areas of California

Teledentistry in India

In 1999, the department of information technology (ministry of coummunications and information technology, govt. of india) launched a pilot project named "Development of telemedicine technology" with aim of improving national health care delivery system at 3 centres.

- All india institute of medical sciences (AIIMS), new delhi.
- Post graduate institute of medical education and research (PGI, chandigarh)
- Sanjay gandhi post graduate institute of medical sciences (SGPGIMS),Lucknow,U.P

Key features of the project was to identify appropriate technological tools and services to implement telemedicine. To develop and carry out system integration to enable telemedicine , teleconsultation and telediagnostic service for speciality of radiology, cardiology and pathology at these centres. Also to train clinicians to use telemedicine technology.

Future prospectives of teledentistry

The advances in telecommunication have rightly enabled the dental care to promise many exciting changes during the next few years (Bimbuch, 2000). The professions and volunteers working in teledentistry education courses should be trained and must have adequate computer knowledge & skills with teaching experience (Schleyer, 1999). The practitioners of teledentistry must have a license in their state for practising (Young, 1996). Dentists working in teledentistry must ensure the security of their systems and data that they transmit. Data encryption, password protection and user access logs can help in deterring most of the people and in protecting patient confidentiality (Golder, 2000). The results achieved so far are very encouraging, setting the road signs for future investigations. The more work and study should be done to use telemedicine in emergency dental conditions, posttraumatic and postoperative controls, postprosthetic patient surveillance etc. Nanotechnologies, stem cell research and control of bioinductive and bioregenerative materials can be extensively studied through telemedicine and teledentistry. Also it can be used in methods is to support the processes of collection, triage, sorting, counting, and analysis of raw electronic data for the purpose of induction in the systems of artificial intelligence.

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