REVIEW
Teledentistry: A Review on its Present Status and Future Perspectives

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ABSTRACT
The review paper is an effort to shed light on the main practical applications of teledentistry for emphasizing potentialities, problems, and applications of this relatively new branch of oral medicine. The paper also highlighted gaps in knowledge and possible future avenues of research on the topic. A systemic review on teledentistry based applications was conducted. The review is an effort to illustrate the current understanding on teledentistry based interventions and dental education programs. A general search was done for relevant books, articles and online matter on the selected topic. Various sources were accessed in order to identify key literature relating to the topic for exploration; the keywords that were used are “internet, information technology, telemedicine, telediagnosis, teledentistry, computer assisted learning, systematic review.” Database that were used for the literature included British Medical Journal, Oxford Journal, Boimed, CINHAL, PubMed and Medline search engine. All these databases were accessed from various internet databases. After doing a refined and advanced search, the researcher conducted manual search and read the abstract of more than 300 related articles which had keywords in their abstract or title and managed to review articles from last 20 years. As with all new innovations and technologies, there are some barriers to the effective use of teledentistry based interventions, these barriers were also discussed. The review has also elucidated uses of teledentistry in various fields of dentistry including oral surgery, orthodontics, and prosthodontics.

INTRODUCTION:
Teledentistry is a fairly new branch of dentistry. Teledentistry, like telemedicine, uses information technology and modern communication systems to deliver healthcare across geographical locations. The emergence of teledentistry as a branch of telemedicine can be traced back to 1994 when a US Military project demonstrated that teledentistry reduced dental treatment costs and proved effective in providing dental care to distant communities living in rural areas.¹ Teledentistry has the potential to improve access to dental health care and lower treatment costs.² According to Fricton and Chen³ teledentistry integrates electronic health records, telecommunication technology, digital imaging, and the internet to provide consultation with dental specialists. Telemedicine based applications for dentistry (teledentistry), have been successfully implemented as models to improve dental education and access to care.⁴ Teledentistry has been particularly effective in dealing with oral health issues in remote and rural health areas where access to dentists and oral health specialists is limited.⁵ Internet has become the backbone of telemedicine and teledentistry, as it offers real-time transfer of information from one part of the world to another. Many of the essential functions of teledentistry are internet based, as are most forms of distant consultations.⁶ Various studies have shown that video conferencing in dental specialist education is suitable for long distance learning in dentistry.⁷

Telemedicine is not a single technology but is part of a wider process or chain of the process. Telemedicine is known to improve this chain and improve the efficiency and quality of health care services.⁸ Teledentistry has also proven to be
Teledentistry has proven merits in increasing health care knowledge, as well as computer skills. Dentists and students can both save time and resources spent on traveling using online Internet-based teledentistry courses. Online CDE has many advantages over traditional on-site CDE. While reviewing the literature, it emerged that although a lot of research has been done on the technical aspects of teledentistry, medico-legal and copyright issues have been addressed only sparsely. To date no standard protocols and well-defined standards exist in the emerging field of teledentistry; although future research should provide the basis of a well-defined standard protocol for teledentistry based consultations. Large randomized controlled trial’s conducted on telemedicine practices have shown that telemedicine sessions improved compliance with medicine and decreased blood pressure. No such study has been done to experimentally establish or reject the efficacy of consultation sessions on dental health. There have been a few studies on the cost-effectiveness of teledentistry, but no major study has been conducted to assess the cost effectiveness of these methods in the last decade. A teledentistry trial conducted over a period of 12 months in 2002 concluded that the cost-effectiveness of teledentistry would improve with greater familiarity and use of equipment. The last decade has seen an explosion of telecommunication technology and the field has taken giant leaps. Intraoral cameras are installed in most dental clinics, and high-speed internet is readily available almost universally at a reasonable cost. Video conferencing has become part of everyday experience. Hence, the advancement in technology may support a wider use of teledentistry in general dental practice.

This paper has reviewed the main practical application of teledentistry for emphasizing potentialities, problems and applications of this relatively new branch of dentistry. This review was carried to shed more light on the subject area and to discover emerging themes.

Methodology

Datasources and search

The purpose of a systematic review is to find, appraise and synthesize evidence from articles taken in order to provide informative empirical answers to research questions. Research questions guide the types of the data to be collected in the study. A general search was conducted to identify key literature relating to the topic for exploration; the keywords used were “the internet, information technology, telemedicine, telediagnosis, teledentistry, computer assisted learning, systematic review.” The database we used for the literature search included British Medical Journal, British Dental Journal, Oxford Journal, Boimed, CINHAL, PubMed and Medline search engine; all these sources were accessed from various internet databases. After running through refined and advanced search the researchers conducted a manual search and read the abstract of more than 300 related articles which had keywords in their abstract or title and reviewed these articles.

Study selection

Inclusion criteria included peer-reviewed journals with full texts, abstracts, and references. All the articles selected were in English language, they were all well referenced; only articles by authors with credibility in the field of study were chosen, all the authors appeared to be experienced in their line of work and all of the articles selected were published in peer-reviewed journals. The same keywords were used in all the databases, the advanced search option was utilized to reduce the quantity of hits obtained. The reference list of all articles was thoroughly hand searched. The exclusion criteria were applied to editorials, letters, debate, economy reports and mismatching subjects. The author excluded all the articles not relevant to the review. A selected sample of the studies selected by the reviewers for their relevance have been summarized to give an account of how every study was selected and analyzed (Table 1). All the studies were
Data extraction
A single rater (S) screened the abstracts for broad suitability. Two investigators (F,M) then extracted relevant information from the full texts such as follow-up period, sample size, relevance, methodology, journal quality, and author credibility.

Quality assessment
Identified papers were further evaluated using the criteria of the Newcastle-Ottawa Scale that allows the assessment of the methodological quality of comparative studies and of case control studies. Overall study quality was defined as poor score (0-4), moderate (5-6) or good (7-9).16

Results
The search returned 854 abstracts, of which 160 (18.7%) were included for further scrutiny out of which a further 92 texts the patient to the dentist thus reducing the cost of treatment.20,21 In our literature review, we found telecommunication by the internet and using video conferencing can be used for improving treatment plan of patients which was illustrated by Ignatius et al. in his research.22 Teledentistry was highly rated by UK general dentists for orthodontic treatment.23 Mandall et al. stated teledentistry can make improvements in referral system for orthodontic treatments.24 General dentists can be supervised remotely by the orthodontic specialist advice which enabled them to improve clinical outcomes. Teledentistry has also been identified as a useful instrument in identifying appropriate new patients in orthodontic referrals.25 Review of the literature also reveals its potential in community dentistry/dental public health, as teledentistry based techniques can provide clear and precise visual/tactile examinations for diagnosing dental caries in young children.26 A research conducted by Amáve et al.27 proved that screening of children by non-invasive techniques can be a valid source. Intraoral camera used now in dentistry is a feasible and cost-effective alternative. A recent case-control study showed that teledentistry based examinations were comparable to clinical examinations while screening for early childhood caries in preschool children.28

The literature provided evidence that further research and training of dental professionals is required to increase awareness about this upcoming field. As E-education in dental education is the best way to deliver dental treatments where they are less human resources and funds.29

Discussion
The central question of this review is to appraise teledentistry based interventions, its global application, as well as its uses in dental education. In rural areas where there is a shortage of resources and dental staff, teledentistry based programs can ease the problem and provide dental care for the remote populations at a reasonable rate.30 Teledentistry can be a very effective tool in providing CDE to dental staff. If one considers the cost of traditional continuing education programs including (travel, lodging, and food) telemedicine based continuing education programs have many benefits over the traditional continuing education programs.31 The role of communication technology in imparting CDE is critical, on-line video conferencing, and web-based on-line training courses are changing the face of distant learning.32 Teledentistry like telemedicine based programs also face a host of issues which are mostly related to technical problems, legal issues and matters of privacy. Issues related to patient confidentiality and privacy need special attention from the operators. The fundamentals of patient privacy in teledentistry based practices will be similar to other E-Health and telemedicine based interventions. Patient privacy must be protected at all times although it is understandable that some privacy might be compromised when such technology is used.33
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<th>Study</th>
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<tr>
<td>Mihailovic et al.</td>
<td>Comprehensive literature review of 67 research articles on the subject of teledentistry</td>
<td>Literature review</td>
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<tr>
<td>Jampani et al.</td>
<td>Systematic review</td>
<td>67 peer-reviewed articles on the subject of teledentistry</td>
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<td>Fricton and Chen</td>
<td>324 participants in the test group and 156 participants in the control group</td>
<td>Test-using teledentistry to improve access to dental care for the underserved</td>
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<td>Chen et al.</td>
<td>56 articles on the subject reviewed</td>
<td>Literature review. The authors describe teledentistry as it is applied worldwide, as well as its uses in education</td>
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<td>Ignatius et al.</td>
<td>24 patients (18 dentists, 2 dental hygienists, and 5 nurses took part)</td>
<td>Consultations took place between a specialist dental treatment unit in a central hospital and general dental practitioners in seven regional health centers. Video conferencing was conducted using standard commercial units via an IP network, at bandwidths of 762 Kbit/s - 2 Mbit/s</td>
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<td>Brullman et al.</td>
<td>50 X-rays of endodontically accessed teeth surfaces</td>
<td>Study on the remote recognition of root canal orifices tested the 50 images of endodontically accessed teeth acquired with an intraoral camera</td>
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<td>Yoshinaga</td>
<td>The study involved documenting 25 cases of oral lesions over a period of 1-year in a primary care public health clinic in Parana in Southern Brazil</td>
<td>Clinical electronic charts and images were produced and sent by email to two oral medicine specialists with a median of 10 years experience in the field. The consultants provided a maximum of two clinical hypotheses for each case</td>
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<td>Summerfelt et al.</td>
<td>Initial training endeavors proved that teaching the data acquisition technologies to 50 dental hygiene students was easily and successfully accomplished: students, with only 6 hours of training, showed their ability to set up, manage remote patient service facilities, and transmit digital diagnostic data from the remote locations that were statistically as efficacious as diagnostic data obtained from an onsite dental hygiene</td>
<td>Described an innovative oral health workforce model on teledentistry assisted, affiliated practice for dental hygienists</td>
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<td>Mandal et al.</td>
<td>200 GDPs were approached from Stockport, Rochdale, Oldham, Bury, and Bolton in Greater Manchester, and High Peak in Derbyshire</td>
<td>Evaluated GDPs opinion about a teledentistry system to screen new patient orthodontic referrals</td>
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<td>Scuffham and Steed</td>
<td>25 patients were recruited into the trial</td>
<td>A 12-month trial of teledentistry was conducted in two general dental practices (one in the Orkney Islands and one in the Scottish Highlands at Kingussie). The dental practices had a PC-based video conferencing link, connected by ISDN at 128 Kbit/s, to a restorative specialist at a hospital in Aberdeen</td>
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<td>Kopycka-Kedziewasaki and Billings</td>
<td>173 eligible children were randomized into two groups: group one received a traditional visual/tactile oral examination, and group two received a teledentistry examination</td>
<td>Assessed dental caries prevalence and dental care utilization in preschool children enrolled in urban childcare centers in a comparative effectiveness study. Caries prevalence was determined in a cohort of children 12-60 months of age.</td>
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<td>Golder and</td>
<td>Review article</td>
<td>The article examines teledentistry and some of its current legal issues. Topics include licensure, malpractice, technology, and...</td>
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<td>Brennan et al.</td>
<td>22 patients who met the inclusion criteria, 104 (85%) consented to participate</td>
<td>RCT. Emergency physicians and nurses were trained in telemedicine techniques in two emergency departments, one rural (low volume) and one suburban</td>
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<td>Toress et al.</td>
<td>Sample included 60 consecutive patients who sought oral medicine services at the Federal University of Paraná, in the state of Paraná, located in southern Brazil</td>
<td>The study evaluated the applicability of telediagnosis in oral medicine, through the transmission of clinical digital images by e-mail. The study was designed with a nonrandomized convenience sample</td>
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GDP: General dental practitioners, RCT: Randomized controlled trial
Misdiagnosis as a result of technical issues can also lead to legal complication for the operator. Medico-legal issues are sensitive and with the involvement of communication technology, which can be susceptible to technical errors, the operators need to be even more careful. Laws of different countries vary and the teledentistry staff needs to make themselves well-acquainted with the legal issues surrounding this technology. National and International Teledentistry based protocol is needed which will act as a uniform of the code of conduct and ease problems associated with privacy, data collection, and diagnostic codes. Others issues that need to be highlighted and addressed before fully harnessing the uses of teledentistry based interventions include cultural tendencies, such as resistance to change, insufficient infrastructure, linguistic barrier, illiteracy, technical, and organizational factors.34

Conclusion

Teledentistry is an innovative and novel addition to dental practice. While reviewing the literature, it is evident that further research is needed to investigate and fill the gaps in knowledge in this field. Many legal and privacy related issues are yet to be resolved. Complex issues emerging due to interstate licensure, malpractice and problems related to jurisdiction will need to be sorted out before the system can be successfully applied internationally. The author also found that there is a lack of standardization when it comes to teledentistry related operations and protocols. Standardization is essential as the technology relies on information technology and is not confined to a geographical location. Stakeholders will need to come together and develop a protocol for teledentistry which is both effective and simple. As far as CDE is concerned, the instructors and teachers need to be sufficiently trained in IT and computer technology. They must also possess relevant teaching experience.35
Teledentistry based intervention strategies can be useful in providing dental treatment to patients in remote locations and to locations where access to conventional dental treatment is difficult. Seafarers on ships represent the perfect example of a remote location with little or no access to medical and dental health care. Ships represent a prototype of remote location and medical care to sailing seafarers can be provided only through telecommunication systems by Telemedical Maritime Assistance Services, one such organization with the most experience in telecommunication medical services, Centro Internazionale Radio Medico, (C.I.R.M), which was founded in 1935. Similar strategies and interventions can also be employed at other distant locations through teledentistry. Hence, the future of teledentistry based interventions looks very bright; it is just a matter of tapping the resources effectively.

References

25. Stephens C, Cook J, Mullings C. Orthodontic referrals


