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Challenges with use of an intra-oral camera for teledentistry in research and practice

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ABSTRACT

Teledentistry, with the use of an intra-oral camera (IOC), can overcome numerous challenges. The visual nature of oral diseases and dental treatments is ideal for practising teledentistry, especially during COVID-19. Images or videos of the oral cavity to evaluate caries, plaque, calculus, tooth wear, fluorosis, and stains can be captured by a trained and calibrated examiner with IOC. The IOC was shown to be a reliable tool to identify common oral diseases. Certain limitations like low illumination can be overcome by using IOC as they are equipped with a light-emitting diode which can offer superior visualisation and inbuilt magnification of the oral cavity. However, there is a possibility of overestimation of the disease. IOC can also be used for patient education through the “show and tell” concept in real-time like showing the areas where the disease may be a concern like plaque, calculus, and early signs of tooth decay. However, it may be challenging to diagnose diseases remotely in real-time and simultaneously seek specialist consultations and recommendations relating to the treatment protocols for numerous conditions. This manuscript reviews the challenges concerning communication, ethics, teamwork, consumables, data storage, and analysis which could be encountered with the use of IOC in this era of teledentistry and COVID-19.



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INTRODUCTION

It is seen as highly advantageous for oral care and dental research, as many conditions are based on direct intra-oral measurement. Diagnosing oral diseases remotely in real-time and simultaneously seeking specialist consultations and recommendations relating to the treatment protocols for numerous oral conditions may sometimes be challenging. Teledentistry, with the use of an intra-oral camera (IOC), can overcome numerous challenges.

COVID-19 has been declared as a pandemic by WHO, and various regulatory authorities instructed oral health care providers to defer elective dental treatments. These recommendations were mainly to protect the oral health care personnel, their fami-

lies, and patients from COVID infection (Odeh *et al.*, 2020).

COVID-19 pandemic would create advancements in telehealth and flexibility in research designs (Rose, 2020). The visual nature of oral diseases and dental treatments are ideal for practising teledentistry (Estai *et al.*, 2016). Oral conditions are often directly visible, and hence, photography may be a valuable diagnostic tool that should not be underestimated in times of epidemics or pandemics. For patients with COVID-19 or those who suspect they may be infected, teledentistry can assist in remote assessment (triage) and continuity of care (Rose, 2020).

Oral conditions like dental pain, Molar-Incisor hypomineralisation, traumatic dental injuries are common among children (Pentapati *et al.*, 2017b, 2020). School-based surveys for the screening of oral conditions could be an ideal situation for the use of teledentistry with IOC. Non-health care personnel like teachers, parents, siblings, and health workers can use an IOC to capture images or record the oral cavity after suitable training. These can be diagnosed or evaluated by calibrated and trained dental auxiliaries, or dentists. Screening for oral conditions can be performed using IOC in dental clinics, schools, or outreach centres among patients requiring (Pentapati and Siddiq, 2019):

1. Diagnosis of hairline fractures, fractured cusps, early stages of potentially malignant disorders, and oral cancer.
2. For more complicated cases, one can easily confer with other experts since high-resolution images will be available during consultation.
3. For patient education, virtual teaching by the "show and tell" method in real-time is possible, like showing the areas where the disease may be a concern like plaque, calculus, and early signs of tooth decay.

Evaluation of many conditions at a single consultation would be tiring for the examiner. Hence, a simple and systematic approach to intra-oral examination using IOC is by using an algorithm which is recommended for the gingival index (Löe and Silness, 1963) wherein the examiner can proceed with examination from right upper to left upper teeth and left lower to the right lower teeth.

Limitations of traditional visual examinations such as low illumination can be overcome by using IOC as they are equipped with a light-emitting diode. They offer superior visualisation due to lighting and magnification of the oral cavity than traditional visual

examination although, there is a possibility of over-estimation of the disease. A further advantage of using IOC over traditional methods of examination would be the repeatability of the IOC images. Evaluation of intra and inter-observer reliability is always recommended.

Appropriate care should be taken while using information from the images. To avoid potential sources of bias in research, identifiers of the participants or patients in the images should be removed. The usage of specially designed software to code or link the data of each participant or patient would be more convenient. This manuscript discusses the various challenges encountered using IOC in this era of teledentistry.

Methodological issues in research and practice

Ethical issues

Ethical issues and confidentiality of dental information come into question when referral of photographs, medical histories, and records; and also from general security issues of electronic data stored in computers when they need to be transferred (Sfikas, 1997). The dentist and oral health care professionals should be attentive and give adequate care when using the information to ensure the privacy of the patients is maintained and prevent unauthorised access to this data. However, awareness to the patients of the possibility of their information getting transmitted electronically and intercepted, despite most efforts to maintain security should be well explained beforehand. The potential harms and benefits have to be explained in detail to the participants. There can be an issue of language barriers in communicating with the patients which need to be addressed by including researchers or clinicians who are proficient in local vernacular.

The proper methodology of conveying patients the possible transfer of their information has to be followed. Usage of informed consent in teledentistry covers every aspect present in a standard, traditional consent form, including details of the inherent risk of improper diagnosis or treatment due to the failed technology that was used (Golder and Brennan, 2000). Parental informed consent has to be obtained in situations where children and adolescents below 18 years or as per prevailing laws of the geographical area.

Medico-legal issues, privacy, confidentiality, and security, along with remuneration for participation in research, are some areas of concern that arise due to a lack of well-defined standards (Sanders and Bashshur, 1995). Currently, there is no consensus to assure quality, safety, efficiency, or effectiveness of

data or its exchange in the use of teledentistry for research and practice.

It is mandatory for the researchers and health care providers who choose to work on teledentistry to educate themselves about the issues relating to the legal, technological, and ethical aspects of this new practice medium prevailing in their respective field practice areas (Golder and Brennan, 2000).

Teamwork

An active team of clinicians/researchers is needed to oversee the process. World Health Organization (2013) guidelines state for calibration between the researchers by an experienced examiner, including training sessions for the investigators on participants with a wide range of oral conditions for two days, followed by calibration on 20 preselected participants (World Health Organization, 2013). Such a methodology would help in reducing bias and differences in the clinical examination. Appropriate reliability exercises can be executed with a sufficient washout period.

Consultants or specialist have to rely on the examinations conducted by the dental team at the remote site as they cannot perform hands-on examination. Therefore, good communication and understanding between a dentist working in a remote area and the specialist should be there. Any areas which required additional documentation may be photographed. The quality of the video recordings or photographs has to be evaluated by another examiner before discharging the participant.

Communication

Teledentistry has the potential to integrate oral health into the delivery of a more extensive health care system by promoting improved interactive and interpersonal communications with other health care experts, namely: paediatricians, radiologists; and nutritionists (Bauer and Brown, 2001). Patients may seek consultation with the referring practitioner, nurse, dental hygienist, or telehealth aid in the school premises, dental office, childcare centre, or other facility equipped with IOC.

Though Internet-based Teledentistry has taken preference over other means of communication, potential inadequacies exist, like – a requirement for proper training, stress for an immediate response, misunderstanding of messages and concepts, concerns of confidentiality, and possibility of potential negligence or tendencies to overlook the messages (Graschew and Roelofs, 2011). There is always a need to schedule and coordinate the appointments of participants, health care providers, and a specialist consultant to have effective real-time consulta-

tion. If such coordination is not possible, videos or pictures can be recorded which can be transmitted by store and forward method for teledentistry consultation.

The English language is the medium used in most of the teledentistry-based education programs and consultations. A universal tool such as the internet is used widely around the world, and the future goals should consider the inclusion of multilingual programs so that patients may consider using them directly without the help of other oral health care personnel.

Consumables for effective infection control measures

The IOC resembles a pen, typically outfitted with a disposable protective sheath for each new patient. Sleeves for IOC, including barrier protection, is a necessity. The camera is exposed to patients' saliva and blood, making it a potential source of infection that needs decontamination after each use. The device cannot get too wet, and the lens cannot be autoclaved. Failure to follow the infection control protocol can result in damage to the expensive equipment or potential cross-contamination between patients. Given those restrictions, training oral health care personnel to maintain an aseptic protocol for an IOC is a high priority along with other barrier protection. Cross-contamination is a challenging aspect to be looked into while using such technology (Kohn et al., 2003). Various disinfection agents (ethanol, povidone-iodine, hydrogen peroxide, glutaraldehyde, sodium hypochlorite) are currently available for surface disinfection of equipment that cannot be sterilised. One should be aware of the compatibility of these surface-active agents and the equipment along with no or minimal residual effects to the participants. Agents like hydrogen peroxide, sodium hypochlorite, and povidone-iodine (Kanagalingam et al., 2015; Kariwa et al., 2006; Pattanshetty et al., 2020) are shown to be effective in reducing the viral load of COVID-19 (CDC, 2008). However, the compatibility of these solutions on the IOC has not been evaluated.

Data storage and Internet connection

Digitisation of data is required in teledentistry. The data stored can be used retrospectively and or for cohort studies and surveys. We have used portable hard discs to save the recorded videos. Alternatively, one can use cloud-based data storage services that have enhanced security features that can prevent any unauthorised access, unlimited storage, accessibility in multiple locations, and devices. Such a function can be useful to even share the data with the patient for future reference or to cross-refer to

clinicians for any second opinion.

Current IOCs are improvised for general practice; however, modifications are employed according to the technology used. A significant aspect here is the reduction in the bulk of hardware, which has highlighted the vital role of software-based technologies. Storage requirements initially focussed on the need to transfer images from a memory card to a computer. Recent technology has incorporated 'Direct Capture to Computer', providing excellent value and efficient dental diagnoses.

IOC images are saved in the in-built memory or can be stored in the computer. In-built registered software assists in digitally archiving patient photographs and videos. The development of cordless IOC has led to the easy transfer of videos and images in real-time as well as display in the monitor, with in-built tools like Bluetooth and Wi-Fi connectivity. These recent developments have been shown to increase the portability and performance among health care experts (Pentapati and Siddiq, 2019). Researchers can plan based on their requirements and resources, keeping in mind all the above possible aspects.

Analysis

There were no validated dental indices for use with teledentistry, and we have used dichotomous variables (present /absent) for the assessment of various oral health conditions at the tooth level. Methods like the Kappa coefficient and Gwet AC1 can be used for evaluating reliability for categorical variables. Other methods like intra-class correlation, Bland Altman plots, Mountain plots, Passing Bablok regression, or Deming regression can be used for validated indices that give overall scores (continuous variables) for each patient. However, such methods are not commonly reported and require the expertise of statisticians from the planning stage of the study.

DISCUSSION

Various oral conditions that can be diagnosed using an IOC include but not limited to are (Pentapati et al., 2017a):

1. Diseases of the teeth such as caries, pulpal exposure, pulp polyp, fractured teeth, malocclusions, developmental defects, 3rd molar impactions, fluorosis
2. Teeth related such as stains, plaque, calculus
3. Soft tissue conditions such as pre-malignant and malignant lesions, inflammatory diseases, oral mucosal, gingival, periodontal conditions

Teledentistry may only help in preventive and diagnostic procedures. Chairside investigations requiring tactile, probing, palpation, and percussion for diagnosis cannot be done with the use of IOC. Only oral conditions that can be seen or perceived visually can be diagnosed using such a technology.

Pictures captured using teledentistry provide superior features of the oral cavity than the traditional method of visual examination. However, the former method can overestimate disease levels. The use of teledentistry should be limited for preliminary screening after which confirmation of the diagnosis should be made clinically when feasible. Furthermore, it counters possible dental care roadblocks such as lack and cost of transportation, saves time from school and work, and patient's money.

Numerous indices have been developed in the past that can aid the clinician in diagnosing oral conditions. But none of these indices has been validated to use with teledentistry. Only a few indices such as indices on caries (DMFT), plaque, gingivitis, fluorosis, and dental trauma have been evaluated.

A previous study reported that immature plaque with a disclosing agent could not be demonstrated clearly with an IOC (Pentapati et al., 2017a). The low resolution/bright illumination was the reason for the lack of discrimination. This may be resolved by newer IOCs which have plaque mode or by using a better disclosing agent. Difficulty in visualising the distal side of the last management molar using IOC has also been reported previously (Pentapati et al., 2017a). IOC might be useful in the assessment of pre-malignant lesions, recurrent aphthae, gingival recession, and dental malocclusion. Moreover, in cases of limited mouth opening, IOC could be a suitable alternative.

The use of IOC in capturing images can generate numerous images for a single patient's mouth and can be cumbersome. Simultaneous labelling of the photos would be essential to avoid confusion from too many image files. Documentation by videos would be preferred over an image using IOC. However, such a file would be too big and can create problems in archiving. With advances in technology, IOCs can also be connected to mobiles for better-operating efficiency (Vinayagamorthy et al., 2019).

The target population for applying teledentistry includes the elderly population living in nursing homes; school children and annual dental screenings, and rural, tribal communities since they're far removed from the nearest dental practice. Awareness and training need to be given to parents of young children and adolescents for teledental consultation regarding dental trauma because even

educated mothers have a low knowledge level about traumatic dental injuries (Parvathy *et al.*, 2019). With the tobacco epidemic continuing and increasing use of tobacco, the IOC can be used in early diagnosis of tobacco use (Kurupath and Sureka, 2018), monitoring of oral changes like stains and potentially malignant lesions and to provide appropriate care.

Recommendations

1. In India, Primary health centres and community health centres can be equipped with teledentistry to facilitate education and better services for society. Midlevel oral health care providers can be appointed in rural and tribal areas, who can provide cost-effective dental care and specialist consultation when supported through teledentistry.
2. The instructors and trainees of the teledentistry education courses need to be well versed with computer knowledge
3. Standardised referral digital forms can be made to aid in teledental referrals, which can be facilitated by developing dedicated software and mobile applications.
4. Taking routine clinical images of the oral cavity with the patient's consent should be encouraged by the dental professionals as this improves the quality of referrals and appropriate documentation of patient clinical records.
5. Future research should aim at assessing the cost-effectiveness of practising a community-based teledentistry service over traditional consultant-led clinics.

CONCLUSION

With lessons learned from the COVID-19 pandemic, the traditional classrooms becoming virtual classrooms, oral health care professionals can consider establishing virtual dental clinics. The results from the published studies are promising, setting the path for future research. Further studies are required to validate the various oral health outcomes using teledental applications.

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Conflict of Interest

The authors declare that they have no conflict of interest for this research.

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