IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 24, Issue 10 Ser. 4 (October. 2025), PP 33-37
www.iosrjournals.org

Tele Dentistry In Oral Pathology: Applications, Evidence, And Future Directions

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Abstract:
Teledentistry, defined as the use of telecommunication and digital technologies to deliver dental care at a distance, has emerged as an effective tool in the field of oral pathology. Limited access to oral pathology specialists, particularly in rural and underserved areas, often leads to diagnostic delays and compromised patient outcomes. Teledentistry enables remote consultation, diagnosis, and follow-up of oral mucosal lesions and potentially malignant disorders through digital image sharing, teleconsultation, and telepathology. Several studies have demonstrated that teledentistry offers diagnostic accuracy comparable to conventional face-to-face examinations. It facilitates early detection of oral lesions, reduces the need for unnecessary referrals, and enhances collaboration between general practitioners and specialists. Furthermore, it supports continuing dental education by providing platforms for case discussions and remote mentorship. Despite its advantages, challenges such as inadequate image quality, lack of standardized imaging protocols, limited tactile assessment, and medico-legal issues continue to hinder widespread adoption. Integration of artificial intelligence and improved digital infrastructure may further enhance its diagnostic potential. Overall, teledentistry serves as a valuable adjunct to traditional oral pathology practice, promoting accessibility, early diagnosis, and improved patient care while paving the way for a more connected and technology-driven approach to oral health services.

Keywords: *Teledentistry, Oral pathology, Telepathology, Oral lesions, Digital diagnosis, Remote consultation.*

Date of Submission: 12-10-2025 Date of Acceptance: 22-10-2025

I. Introduction:

Teledentistry has been in use for many different dental applications for many years and the advantages are unquestionable. Those advantages include educating patients and students about dentistry, providing access to specialized dental care to patients in rural and remote areas, decreasing the amount of time it takes to get treatment once a diagnosis has been made, and cheaper transportation related costs. Existing literature has described teledentistry as a dental practice in cariology, medicine and oral pathology, endodontics, and oral radiology, in addition to studying it as a method for dental education [1]

It is common knowledge that many dentists need to build their comfort level with teledentistry with its many applications. In addition, it has been noted that the general dentist can find it challenging for the detection of oral lesions specifically for potentially malignant mucosa disorders. In this same vein, calls and consultations with an oral pathologist can give accurate diagnosis of oral lesions, shorten the time for obtaining a diagnosis and obtaining treatment (if not to surgical sampling of lesions for microscopic examination), refer patient for treatment, if necessary, and improve early detection for oral cancer and access to specialized dental care in underserved rural communities. Oral pathology deals with disorders of the oral and maxillofacial region — diagnosis of lesions, mucosal disorders, potentially malignant conditions, malignancies, infections, etc. Access to specialists is often limited in rural, remote, or underserved areas. Teledentistry (remote consultation/diagnosis via digital images, telecommunication tools) has emerged as a promising tool to bridge this gap. It allows practitioners to share clinical data, images, and history with oral pathology experts, reducing delays, travel, cost, and improving early diagnosis[1]

II. Application Of Teledentistry In Oral Pathology

Here are some of the key uses:

1. Diagnosis of Oral Mucosal Lesions
- Remote evaluation of suspicious lesions (ulcerations, white/red patches, leukoplakia, erythroplakia, etc.). Clinicians in remote settings can take images (photographs, smartphone images, intraoral cameras) and send them for specialist review.
- Example: A study from "Frontiers in Oral Health" described an institutional experience over 7 years where remote examinations (both synchronous and asynchronous) were used to evaluate lesions, many suspected malignant or of reactive/infectious origin. The remote consultations helped in diagnostic impressions and differential diagnoses, and in many cases histopathological confirmation[2]

2. Screening for Potentially Malignant Disorders (PMDs) / Oral Potentially Malignant Disorders (OPMDs)
- Teledentistry can help in screening for OPMDs in populations where specialist clinics are distant. Examples include systematic reviews comparing telediagnosis vs face-to-face clinical oral examination (COE) for OPMDs, showing reasonable diagnostic accuracy[3]
- Early detection is crucial, because early treatment of PMDs may prevent malignant transformation.

3. Consultation and Referral
- General dentists or primary health care providers can consult with oral pathology experts ("tele-consultation") to get advice on whether a lesion requires biopsy, what type of biopsy, follow-up etc. This reduces unnecessary surgery and costs.
- Also useful in triage – deciding urgency.

4. Support for Histopathology
- Although histopathological diagnosis still requires tissue sampling and laboratory evaluation, teledentistry helps in the decision-making process: whether a biopsy is needed, what lesion types to consider, pre-operative planning. In some cases, digital images of histopath slides are shared (telepathology) for consultation.

5. Monitoring & Follow-up
- Post-procedure follow-up (after biopsy, treatment) via teledentistry to check healing, recurrence.
- Monitoring of OPMDs for changes (size, colour, symptoms) without requiring frequent in-office visits.

6. Education and Training
- Teaching dental students, general practitioners, and health workers on lesion recognition using digital images and remote mentorship.
- Sharing of case-libraries and teleconsultation sessions as learning experiences.

7. Tele-Pathology / Digital Pathology
- Using scanned histopathology slides (whole slide imaging) combined with telecommunication allows remote pathologists to review cases.
- May speed up diagnosis timelines, especially in areas where trained oral pathologists are few.

Evidence And Diagnostic Accuracy:
- Studies, mostly from developing countries are using tools like smartphones, videoconferencing, email, etc. The level of agreement between teledentistry-based diagnosis and in-person clinical examination was generally high[4]
- The diagnostic meta-analysis compared telediagnosis vs COE for OPMDs. Sensitivity and specificity were promising, though variable across studies[5]
- The institutional case series from ECU School of Dental Medicine (over 71 patients) showed that teledentistry not only decreased travel and number of visits but also increased speed of diagnosis, particularly for lesions suspected of malignancy[6]

Benefits:

1. Increased Access

Teledentistry bridges the gap between patients and oral pathology specialists, particularly in rural or remote areas where expert care is limited. By enabling virtual consultations, it ensures that patients receive timely evaluation and professional guidance without the need to travel long distances.

2. Reduced Cost & Travel Time

Virtual consultations minimize transportation expenses and clinic visits. This not only makes care more affordable for patients but also reduces time lost from work or daily activities, making dental care more accessible and efficient.

3. Early Detection

Through remote screening and early evaluation of suspicious lesions, teledentistry facilitates prompt diagnosis of oral diseases and potentially malignant disorders. Early detection allows for earlier intervention, improving treatment outcomes and survival rates.

4. Efficient Triage & Referral

Teledentistry helps general practitioners determine which cases require urgent biopsy or specialist attention. This structured referral process prevents both unnecessary referrals and delays in managing serious lesions.

5. Education & Capacity Building

Teledentistry also serves as a platform for continuous professional development. By interacting with specialists through teleconsultations, general dentists and health workers enhance their diagnostic knowledge and clinical decision-making skills, ultimately improving overall oral healthcare delivery.

III. Challenges And Limitations:

1. Image Quality & Standardization

High-quality images are essential for accurate diagnosis, but poor lighting, low resolution, and inconsistent imaging angles can lead to misinterpretation. Lack of standardized imaging protocols makes it difficult to ensure diagnostic reliability across different settings.

2. Lack of Tactile Information

In oral pathology, physical examination often provides key clues—such as lesion firmness, surface texture, and depth. These tactile sensations cannot be captured through images or video, limiting the completeness of remote assessments.

3. Need for Biopsy & Histopathology

While teledentistry aids in preliminary diagnosis and triage, confirmation of many oral lesions—especially potentially malignant or neoplastic conditions—requires biopsy and microscopic examination. Thus, teledentistry serves as an adjunct, not a replacement, for traditional pathology.

4. Legal, Ethical & Privacy Concerns

Handling patient data digitally raises concerns about confidentiality, data protection, and patient consent. Moreover, legal issues such as practitioner licensure and cross-border consultations require clear regulations to ensure accountability and patient safety.

5. Internet / Technology Access

Reliable internet connectivity, proper hardware (cameras, software), and technical infrastructure are crucial. In rural or low-resource areas, limited access to technology can hinder the effectiveness of teledentistry programs.

6. Training of Clinicians

Both image providers (e.g., general dentists, health workers) and image evaluators (specialists) require training in image capture, case documentation, and digital communication to maintain diagnostic quality and consistency.

7. Diagnostic Accuracy Variability

Studies show variable sensitivity and specificity in telediagnosis of oral lesions. Factors like image quality, clinician expertise, and lesion type can influence accuracy, highlighting the need for further research and validation.

IV. Future Directions:

1. Improved Imaging Tools & Protocols

To ensure accurate remote diagnosis, standard guidelines for capturing intraoral images are essential. This includes recommendations for lighting, angulation, magnification, and camera resolution. Standardization minimizes diagnostic errors caused by poor image quality and ensures consistency across teleconsultations.

2. AI / Machine Learning Integration

Artificial intelligence (AI) can be trained to identify patterns in oral lesions, classify disease types, and assist in early screening. Machine learning algorithms can help in triaging patients, prioritizing urgent cases, and even providing preliminary diagnostic suggestions. Such systems can support specialists and improve efficiency, especially in high-volume or remote settings.

3. Telepathology / Whole Slide Imaging

Advances in digital pathology allow histopathological slides to be scanned and shared virtually. Remote oral pathologists can then review these high-resolution slides for diagnosis. This enables faster reporting, access to expert opinions, and collaboration between institutions, reducing turnaround times and improving patient outcomes.

4. Hybrid Models

A combined model of care — where teledentistry is used for initial screening and in-person visits are reserved for biopsy, treatment, or follow-up — offers a practical approach. This hybrid system ensures both efficiency and clinical accuracy while reducing unnecessary visits.

5. Policy & Legal Frameworks

For teledentistry to be widely adopted, clear policies regarding practitioner licensure, patient consent, data privacy, reimbursement, and clinical responsibility are crucial. Establishing these frameworks ensures ethical practice, patient safety, and standardization across regions.

6. Research & Validation

There is a need for more robust clinical studies assessing the diagnostic accuracy, cost-effectiveness, and long-term outcomes of teledentistry in oral pathology. Evidence-based data will help establish standardized protocols and encourage wider clinical adoption.

7. Public Awareness & Education

Educating both patients and healthcare workers about the benefits and use of teledentistry encourages early detection of oral lesions. Awareness programs and training can improve participation, reduce stigma around virtual care, and empower community health workers to identify and refer suspicious cases promptly.

Case Example: Institutional Experience (Front. Oral Health, 2023)
Setting: ECU School of Dental Medicine + satellite clinic over 7 years[7]
Patients: 71 remote consultations for oral lesions; many with suspected malignancy or reactive/infectious conditions[8]
Approach: Asynchronous remote consultations were predominant; comparing clinical impression via teledentistry with final diagnoses after biopsy or follow-up[9]

Findings:
- Teledentistry helped reduce travel and number of appointments.
- Speed of diagnosis improved.
- Clinical impressions via remote evaluation aligned reasonably with final diagnoses[10]

Implications for India / Low- & Middle-Income Countries (LMICs)

Given the disparity in specialist oral pathologists in many parts of India/world, teledentistry has particular relevance. Challenges (connectivity, infrastructure, training) exist, but with increasing smartphone penetration, better internet, and tele-health policies, there is large potential. Projects in Brazil, India, other LMICs already show teledentistry being used for screening, diagnosis, consultation.

V. Conclusion:

Teledentistry offers a powerful adjunct to conventional oral pathology practice. It is not a replacement but can significantly enhance:
- Early detection of lesions and OPMDs

- Access to specialist diagnostics
- Efficient triage and referral
- Cost and time savings

To maximize its benefit, we need standardization of protocols, improvements in imaging and connectivity, integration of AI tools, policy/regulatory frameworks, and more evidence from well-designed studies in diverse settings.

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