RECENT ADVANCES IN DIAGNOSTIC ORAL MEDICINE

Abstract

In the evolving realm of dentistry, diagnostic oral medicine plays a vital role in early detection. This chapter explores recent advancements providing accurate, efficient, and non-invasive methods for identifying oral lesions, caries, and periodontal diseases. Key areas include novel techniques such as chemiluminescence, optical spectroscopy, brush biopsy, and salivary genomics. Advanced caries detection techniques like fiber-optic transillumination (FOTI), Diagnodent, and Cariescan Pro TM offer efficient alternatives. Periodontal disease diagnosis advances through microbial tests, biochemical tests, and molecular biology tests.

These innovations empower dentists to deliver timely interventions, tailoring treatment programs for enhanced patient outcomes. By embracing these tools, oral healthcare professionals can provide personalized, evidence-based care, contributing to improved oral health and quality of life. This chapter serves as a concise guide for navigating the transformative landscape of diagnostic oral medicine, emphasizing precision and patient-centric approaches in oral healthcare.

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I. INTRODUCTION

In the ever-evolving field of dentistry, diagnostic oral medicine is crucial role for the early detection and management of several oral conditions. Recent advancements in diagnostic techniques have paved the way for more accurate, efficient, and non-invasive methods for identifying oral lesions, caries, and periodontal diseases. These innovations have transformed oral healthcare by empowering dentists to offer prompt interventions and individualised treatment programmes, which ultimately enhance patient results.

This chapter explores cutting-edge advancements in diagnostic oral medicine, focusing on novel approaches that have transformed the way oral conditions are diagnosed and managed. By delving into these recent developments, oral healthcare professionals can gain a comprehensive understanding of the tools and techniques at their disposal. Embracing these advancements empowers dentists to deliver more personalized, evidence-based, and effective care to their patients, ultimately leading to improved oral health and the quality of life.

II. ADVANCES IN DETECTION OF ORAL LESIONS

1. **Chemiluminescence:** Chemiluminescence, the captivating light that a chemical reaction emits, has long piqued the interest of scientists. From ancient Chinese literature documenting bioluminescence in fireflies to the pioneering work of Henning Brand in 1669, this captivating phenomenon has now found diverse applications in various fields, including oral oncology. In the pursuit of early cancer detection, chemiluminescence has emerged as a promising optical technique, offering a non-invasive and real-time approach to identify dysplastic and neoplastic tissues in the oral cavity.

    - **Working Principle:** The procedure entails rinsing the mouth with a 1% solution of acetic acid, which serves as a cytoplasmic dehydrator, removes debris, and breaks down the glycoprotein barrier on the epithelial surface. After this, the aspirin (acetyl salicylic acid) and hydrogen peroxide in the Vizilite capsule are activated by flexing the flexible plastic shell of the capsule. It contains a hydrogen peroxide vial inside that is fragile and breaks when activated, causing a chemical reaction that lasts for about 10 minutes and emits blue-white light (430–580 nm). Normal mucosa appears blue under chemiluminescent light, while dysplastic and neoplastic tissues have a distinct "acetowhite" appearance because of altered light refractile properties.

    - **Advantages**

        - **Early Detection:** Chemiluminescence allows for early detection of dysplastic and neoplastic tissues, facilitating prompt intervention and potentially improving patient outcomes.
        - **Non-Invasive and Real-Time:** The technique is non-invasive, making it well-tolerated by patients, and provides real-time results during the examination, streamlining the diagnostic process
        - **Easy to Use:** Chemiluminescence is a chair-side test that is easy to perform, enabling wider implementation in clinical settings.

- **Limited Operator Variability:** The technique shows limited operator variability, reducing the potential for inconsistent results across different clinicians.

- **Limitations**

  - **Costly:** Chemiluminescence-based devices and their consumables can be relatively expensive, which may limit their widespread adoption in certain healthcare settings.
  - **Darkened Environment Requirement:** To achieve accurate visualization, chemiluminescence requires a darkened environment, which might not always be feasible or practical.
  - **Biopsy Site Indication:** The technique lacks the ability to precisely indicate the biopsy site, necessitating further investigations to confirm cancerous lesions.

- **Applications**

- **Oral Cancer Screening:** The method is applied as an adjunct to traditional oral mucosal examination to improve the identification, assessment, and follow-up of oral lesions with a higher risk of developing cancer.
- **Visualization and Marking:** Vizilite Plus combines chemiluminescent technology with the toluidine blue marking system, enhancing visualization and delineation of suspicious lesions for subsequent biopsy procedures.(Figure:1)
- **Medical Device Assisted Detection:** Chemiluminescence has been integrated into medical devices to detect cervical cancer and pre-cancer, highlighting its potential in broader oncological applications.

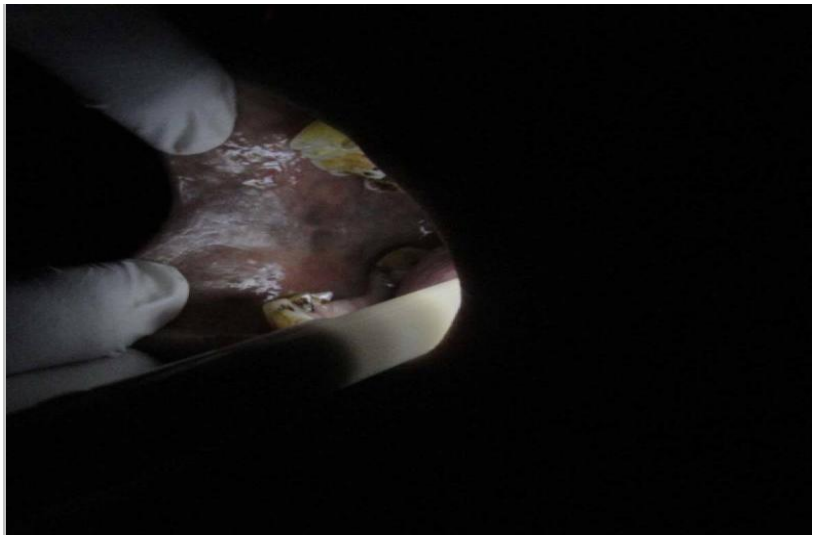

Figure 1: ViziLite testing revealed an aceto-white appearance on the commissure of the lip.

2. **Optical Spectroscopy:** Optical spectroscopy is a remarkable technique that offers real-time, non-invasive, and in situ tissue diagnosis. By analysing the optical spectrum of tissues, valuable information about their histological and biochemical composition can be obtained. Photo diagnosis, a vital optical spectroscopy application, is essential in detecting dysplasia and malignancy, directing biopsies, assessing the haemoglobin tissue

perfusion, and determining the therapeutic drug concentrations during chemotherapy and photodynamic therapy.

- **Working Principle:** Optical spectroscopy relies on the characteristic optical properties of tissues, such as fluorescence, elastic scattering, and Raman scattering. These properties provide valuable insights into the histological and biochemical makeup of the tissue, enabling the differentiation between normal and abnormal tissues.

  Three main techniques used for detecting oral cancer:

  - **Fluorescence Spectroscopy:** Fluorescence spectroscopy involves the detection of fluorescence signals, which can arise either spontaneously (autofluorescence) or through laser excitation and are triggered by the presence of substances known as fluorophores, such as NADPH, collagen, elastin, and cofactors. An elevation in red or green fluorescence levels serves as an indicator of abnormalities like dysplasia and malignancy. The portable VELscope device, utilising narrow-emission tissue fluorescence in the 400–460 nm range, showcases healthy mucosal tissue in a light green autofluorescent hue, while suspicious tissue appears darker.

  - **Elastic Scattering Spectroscopy (ESS):** Elastic scattering spectroscopy is a method that generates a spectrum dependent on wavelength that reflects both the scattering and absorptive characteristics of tissues. ESS exhibits sensitivity to parameters relevant for identifying malignancies, including nuclear size, chromatin content, nuclear-cytoplasmic ratio, and cellular packing density.

  - **Raman Spectroscopy:** Raman spectroscopy is driven by a shift in the frequency of the incident excitation light and provides precise information. However, it should be noted that Raman signals may be relatively weak.

- **Advantage**s

- **Real-Time and Non-invasive:** Optical spectroscopy enables immediate and non-invasive tissue analysis, reducing patient discomfort and facilitating prompt clinical decisions.
- **In Situ Diagnosis:** The technique allows direct tissue analysis in its natural location (in situ), preserving tissue architecture and biochemical composition for accurate diagnosis.
- **Objective and Quantitative:** Optical spectroscopy provides objective measurements, reducing diagnostic subjectivity, and offers quantitative data for better disease assessment and monitoring.

- **Limitations**

- Weak Signals: Some spectroscopic techniques, like Raman spectroscopy, may generate weak signals, potentially reducing sensitivity in specific situations.
- Complex Data Interpretation: Analysis of optical spectra requires expertise and may be complex, necessitating specialized training for accurate interpretation.

- **Applications**

  - Cancer Detection: Optical spectroscopy aids in detecting oral dysplasia and malignancies, facilitating early cancer diagnosis and prognosis.
  - Guided Biopsy: Photo diagnosis assists in guiding biopsy procedures, ensuring targeted tissue sampling and improving diagnostic yield.*(Figure: 2)*
  - Monitoring Treatment: The technique is essential in monitoring the haemoglobin tissue perfusion, and determining the therapeutic drug concentrations during chemotherapy and photodynamic therapy.

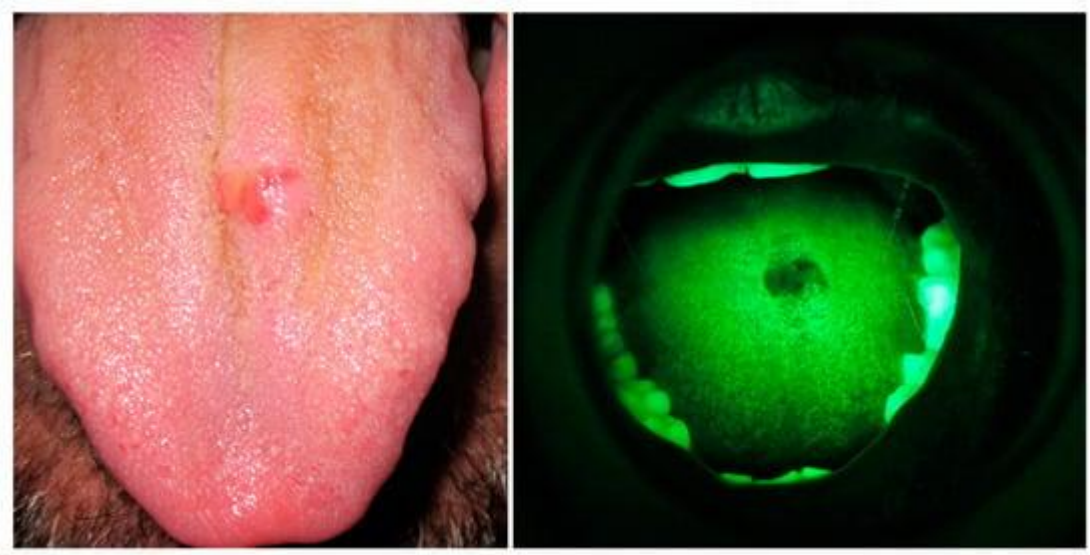

Figure 2: VELscope® results before a tongue biopsy.

3. **Brush Biopsy:** Brush biopsy, also known as oral brush cytology or Oral CDx, is a non-invasive diagnostic technique used to detect oral mucosal lesions that may be precancerous or malignant. It involves using a specialized brush to collect cells from the oral epithelium, which is then analysed for abnormalities. An essential method for screening and early detection of oral cancer is brush biopsy, especially in high-prevalence areas like developing countries.

   - **Working Principle:** The brush biopsy technique utilizes a specially designed stiff bristle brush that can penetrate the thickness of the oral mucosa. The brush is placed on the suspicious lesion and rotated until it produces haemorrhagic spots or reddening.*(Figure:3)* This ensures that a representative sample of cells from the entire epithelium, including the basal, intermediate, and superficial layers, is collected. The collected sample is then fixed and sent to the laboratory for analysis using computer-based imaging systems. Results can be reported as negative (without abnormalities), atypical (uncertain changes), positive (evidence of dysplasia or carcinoma), or inadequate (incomplete sample)*(Table:1)*

Table 1: Result

Negative	**Without Abnormalities**
Atypical	Uncertain Changes
Positive	Evidence of Dysplasia or Carcinoma
Inadequate	Incomplete Sample

- **Advantages**

- **Non-Invasive:** It well-accepted by patients and less painful compared to other biopsy techniques.
- **Early Detection:** It can assist in the early detection of precancerous lesions and oral cancer, improving treatment outcomes and survival rates.
- **Simple and Painless:** The procedure is relatively simple and easy to perform chair-side, requiring minimal time and training for oral health professionals.
- **Reduced Bleeding:** Brush biopsy causes less bleeding during the procedure compared to traditional scalpel biopsies.
- **Cost-Effective:** It can be a cost-effective alternative to surgical biopsies, especially in cases where patients are at low risk.

- **Limitations**

- **Two-Step Process:** In cases where the results are atypical or positive, a second procedure like a scalpel biopsy may be required for definitive diagnosis.
- **Delayed Diagnosis:** The need for additional testing may lead to delays in obtaining a final diagnosis.
- **Indeterminate Results:** Brush biopsy may not provide a definitive diagnosis in some cases, necessitating further investigation.
- **Technical Limitations:** The technique may have certain limitations in diagnosing certain lesions, requiring expertise in cytological interpretation.

- **Applications**

- **Early Detection of Oral Cancer:** Brush biopsy is valuable for detecting oral cancers and precancerous lesions at an early stage, increasing the chances of successful treatment.
- **Screening High-Risk Patients:** It can be used to screen patients with red or white spots, chronic ulcers, orthose with additional abnormal epithelial surface lesions and a high risk of oral cancer.
- **Evaluation of Small Lesions:** Brush biopsy can help evaluate small and suspicious-looking oral abnormalities that may not be obvious during clinical examination.
- **Monitoring Precancerous Lesions:** It is useful for monitoring and evaluating changes in precancerous lesions over time and guiding treatment.

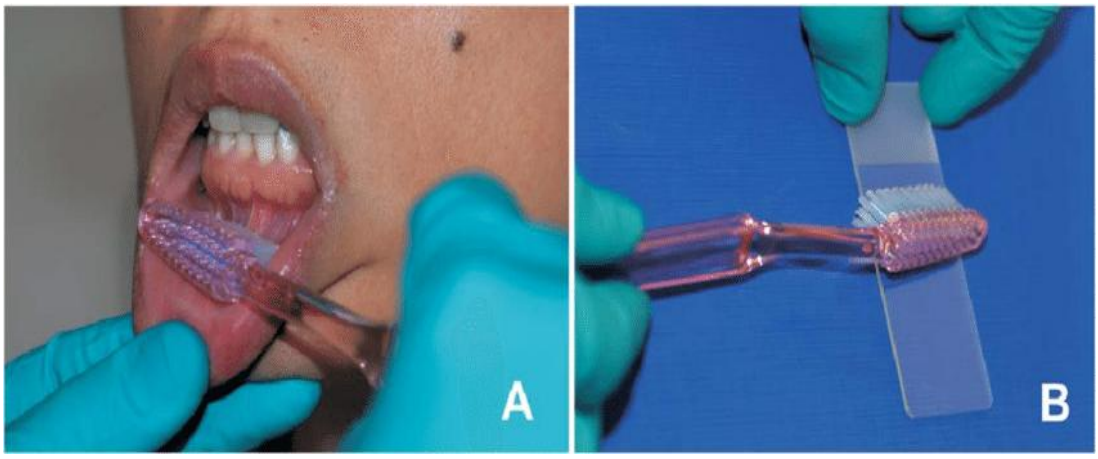

Figure 3: Oral brush biopsy procedure using tooth brush.
A.Using moderate pressure, the tooth brush is brushed in one direction over the entire lesion multiple times.
B. The material from the brush is spread on the two thirds of a clean, dried glass slide

4. **Salivary Genomics and Proteomics Biomarkers:** Salivary genomics and proteomics biomarkers offer significant potential as non-invasive and cost-effective diagnostic tools for oral cancer. Their ease of collection and early detection capabilities make them invaluable in identifying high-risk individuals, guiding treatment decisions, and monitoring therapeutic responses. While further research and validation are needed to establish their clinical utility, the advancements in this field hold promise to transform oral cancer diagnosis and improve patient outcomes significantly.

- **Working Principle:** Salivary genomics and proteomics biomarkers in oral cancer rely on the analysis of genetic material (DNA, RNA) and protein levels present in saliva. The saliva, being in direct contact with oral cancer lesions, contains biomolecules that can indicate the presence and progression of the disease. Various analytical techniques, such as mass spectrometry and electrochemical sensors, are employed to detect specific genetic and protein alterations associated with oral cancer in saliva samples.*(Figure: 4)*

- **Advantages**

  - **Non-Invasive:** Saliva collection is a simple, non-invasive procedure, which reduces patient discomfort and anxiety during diagnostic screening.
  - **Early Detection:** Salivary biomarkers have the potential to detect oral cancer early, allowing for prompt treatment and better patient outcomes.
  - **Cost-Effectiveness:** Saliva-based diagnostics are cost-effective compared to traditional imaging and tissue-based diagnostic methods, making them more accessible to the population.
  - **Multiplexing Capabilities:** Salivary genomics and proteomics enable the simultaneous detection of multiple biomarkers, enhancing diagnostic accuracy and efficiency.

- **Limitations**

  - Cultural Perceptions: Some cultural and behavioral perceptions may present barriers to adopting saliva-based diagnostics in certain populations.
  - Research and Validation: Extensive research and validation are required to identify and establish specific salivary biomarkers that accurately indicate oral cancer presence and Progression.

- **Applications**

  - Early Screening: Salivary biomarkers can be used as primary screening tests for high-risk groups and individuals with premalignant lesions, facilitating early detection and intervention.
  - Prognostication: Salivary genomics and proteomics biomarkers can aid in predicting disease progression and patient outcomes, guiding treatment decisions.
  - Treatment Monitoring: Salivary analysis can be used to monitor treatment responses and assess post-treatment therapeutic efficacy.
  - Multiplex Assays: Electrochemical sensors and mass spectrometry allow for multiplexing, enabling simultaneous detection of multiple biomarkers for more accurate diagnostics.

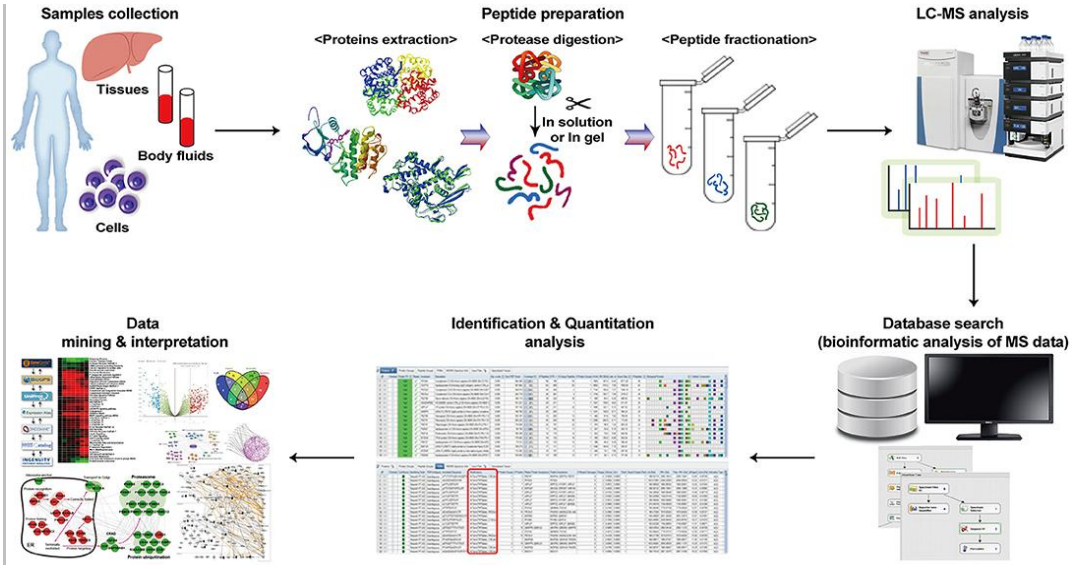

Figure 4: Workflow of the proteomics investigation.
Proteomics exhibit many proteins by peptide preparation, analysis using mass spectrometry, and interpretation of peptide data through existing databases.

III. ADVANCED CARIES DETECTION TECHNIQUES

Advanced caries detection techniques offer a promising future for the early and accurate diagnosis of dental caries. By combining their unique capabilities, dentists can implement effective preventive strategies and provide personalized care to maintain optimal oral health for their patients. As these techniques continue to evolve, they have the potential to revolutionize caries detection and improve overall dental care outcomes.

I. Fiber-Optic Transillumination (Foti): With a wide range of clinical applications, fiber-optic transillumination (FOTI) is a trusted and important adjunctive diagnostic tool in dentistry. FOTI, which is primarily used to diagnose caries, has undergone extensive research and has proven to be a reliable indicator of the histological presence or absence of tooth structure that has been infected by bacteria.

- **Working Principle**

  - Fiber-optic transillumination (FOTI) utilizes thin, flexible cylindrical fibers crafted from high-quality glass or plastic, which are known as fiber optics.
  - This method operates based on Total Internal Reflection (TIR). It occurs when there are variations in refractive indices between the core and cladding materials of the fiber, causing light rays to be reflected back into the fiber core.
  - By directing a focused beam of bright white light across the surfaces of the tooth, including the facial and interproximal areas, FOTI effectively illuminates the translucent tooth structure. This illumination enables the observation of various dental characteristics.*(Figure: 5)*

- **Advantages**

  - Non-invasive and pain-free procedure.
  - Does not expose patients to ionizing radiation, making it safe for repeated use during routine dental examinations.
  - High sensitivity as well as specificity for caries diagnosis, on par or even better than radiographs.
  - Effective for identifying calculus, stained composite resin margins, cusp fractures, cracked teeth, and anterior and posterior interproximal caries.
  - Useful for illuminating root canal orifices and endodontic access, for improving the assessment of soft tissue lesions, and for checking all-ceramic restorations for fractures before cementing.

- **Limitations**

  - Cannot be used as a substitute for standard clinical examinations and radiographs, which are still necessary for the precise diagnosis of a variety of dental pathologies.
  - Effectiveness may be limited in cases where caries are not visually accessible, especially on posterior proximal surfaces.
  - To achieve the best visualisation, specialised light sources with small apertures are necessary because "blue light hazards" could be caused by conventional curing lights.

- **Applications**

  - It serves as an additional diagnostic tool for identifying cavities between front and back teeth and diagnosing cavities on the chewing surfaces.*(Figure: 6)*
  - It can detect the presence of dental calculus.
  - It is useful for assessing the discoloured edges of composite resin fillings and examining damage to tooth cusps and cracks.

- It serves as a tool for exploring and illuminating access points in root canals and endodontic procedures.
- It enhances the assessment of soft tissue abnormalities.
- It aids in clinically evaluating cracks and fine lines in both existing all-ceramic dental restorations and natural teeth.
- It helps assess the extent and nature of external staining to determine appropriate treatment recommendations.

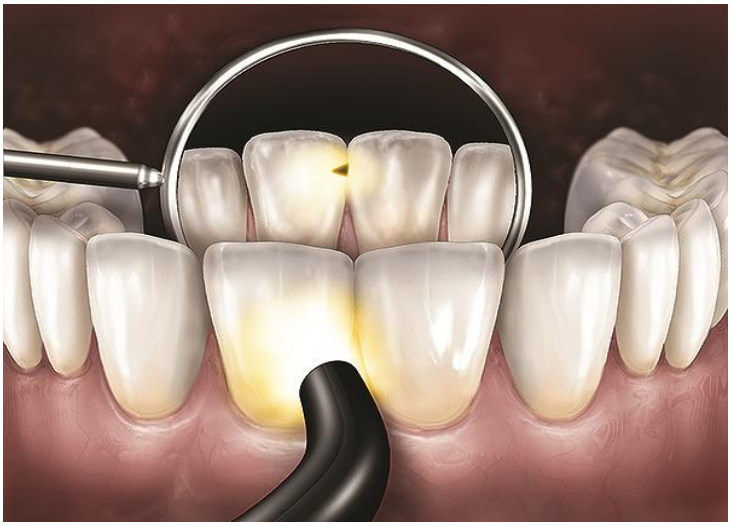

Figure 5: Technique to visualize anterior caries.

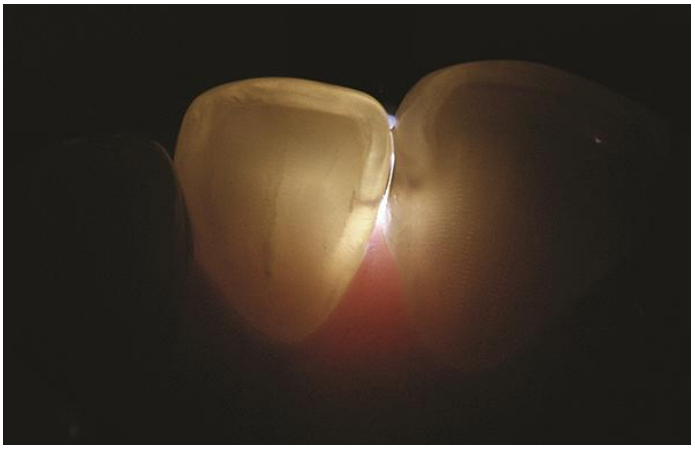

Figure 6: Lingual FOTI position reveals caries on mesial surface of mandibular incisor.

II. Laser Fluorescence System (Diagnodent - Kavo, Biberach, Germany): Caries prevalence has declined in recent decades, but the occlusal surface has become the most affected area due to changes in lesion behaviour. Traditional diagnostic methods using a dental mirror and probe have limitations and bitewing radiographs' accuracy for occlusal caries diagnosis is questioned. A novel technique that uses laser-based fluorescence measurements has been gaining acceptance.*(Figure: 7)*

- **Working Principle**

  - The laser device emits red light that is absorbed by organic and inorganic substances in dental tissues and metabolites from oral bacteria.
  - Because carious tissue contains metabolites like porphyrins produced by oral bacteria, it emits more fluorescent light than healthy tissue.
  - This fluorescence difference enables the device to detect and distinguish carious lesions from healthy structures.

- **Advantages**

- High sensitivity and specificity: The laser method shows good diagnostic accuracy in the detection of non-cavitated occlusal caries in dentin.
- Non-invasive: It provides a non-invasive means of detecting carious lesions, reducing the need for explorers that can damage enamel.
- Early detection: The device allows for early caries detection, enabling timely intervention and preventive care.

- **Limitations**

  - False positive results: The device can produce false positive results, leading to unnecessary treatments.
  - Recommended as an adjunct method: Due to the potential for false positives, it is suggested to use the laser method alongside visual inspection to improve accuracy.

- **Applications**

  - Diagnosis of non-cavitated occlusal caries: The laser method is particularly useful for detecting caries in occlusal surfaces, which can be challenging with traditional methods.
  - Early intervention and preventive care: The device enables early detection of caries, allowing for timely intervention and preventive measures.

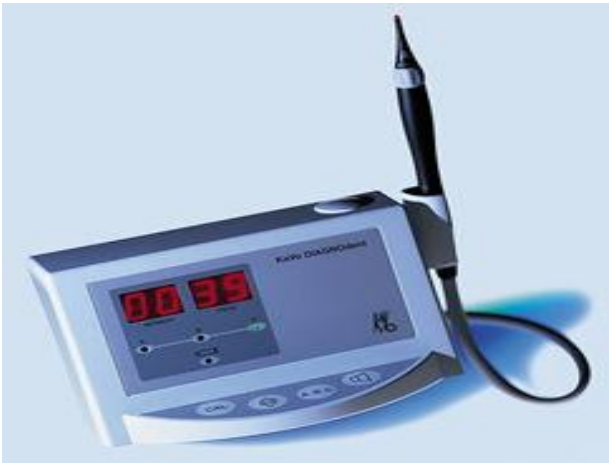

Figure 7: The Diagnodent caries detection instrument.

III. Electrical Conductivity Measurements - Cariescan Pro Tm: In modern dentistry, the early and accurate detection of dental caries (tooth decay) is crucial for effective treatment and prevention. Advancements in technology have introduced electrical conductance and resistance-based methods as valuable tools for caries detection. This technique measures the electrical conductance in teeth, where demineralization creates a conductive pathway for electric current. It has shown superior results in detecting non-cavitated occlusal lesions of posterior teeth compared to visual examination and radiographs.

- **Working Principle:** The idea behind using electrical conductance for caries detection is based on the idea that healthy enamel conducts electricity poorly due to its low porosity and low fluid content. However, as caries lesions grow, there is an increase in porosity and fluid content, which results in greater electrical conductance. Various electrical conductance-resistance-based devices created in recent decades are built on top of this.

  Using AC impedance, CarieScan PRO TM evaluates the electrical behaviour of dental tissues. Electrical impedance spectroscopy provides a more thorough understanding of the tissue under study by measuring impedance at a variety of AC frequencies. The CarieScan PRO is a point system that offers scanning-related real-time readings at a particular location.To identify various stages of non-cavitated lesions, it generates a score and colour reading between 0 (green = sound) and 100 (red = lesion cavitation).

- **Advantages**

  - Non-invasive method: The electrical conductance-resistance approach provides a non-invasive means of detecting caries.
  - Early caries detection: The method allows for early detection of non-cavitated lesions before cavitation occurs.
  - Differentiation of lesion stages: The scoring system provides colour readings that indicate different stages of non-cavitated lesions.
  - Applicability to occlusal and smooth surfaces: The probe can be used on areas with direct access, such as occlusal and smooth surfaces.

- **Limitations**

  - Limited applicability to certain lesions: The method cannot detect cavitated, root caries, or secondary caries lesions.
  - Limited Applicability to Primary Teeth: The suitability of the scoring system for primary teeth may be constrained since it relies on research conducted in laboratory settings with permanent teeth.
  - Potential for Interference: The device may disrupt the accuracy of measurements when in contact with certain dental materials in specific situations.
  - Limited Use with Specific Health Conditions: It is not recommended to use the instrument on individuals with implanted cardiac pacemakers due to potential safety concerns.

- **Applications**

  - Early caries detection: The method is useful for detecting non-cavitated lesions in the early stages before significant damage occurs.
  - Monitoring caries progression: The electrical conductance-resistance approach can aid in monitoring the progression of non-cavitated lesions over time.
  - Assessment of enamel maturity: The method can assess the maturity of enamel based on its electrical conductivity.
  - Detection on accessible tooth surfaces: The probe is suitable for use on occlusal and smooth surfaces where direct access is possible.

Figure 8: CarieScan PRO

IV. ADVANCES IN PERIODONTAL DISEASE DIAGNOSIS

Periodontal disease and salivary gland disorders are common oral health conditions that require accurate diagnosis for effective management. Diagnosis plays a crucial role in identifying and treating periodontal diseases effectively. Conventional clinical and radiographical methods have limitations in detecting early disease activity. To overcome these limitations, advanced diagnostic tools and techniques have been developed, offering non-invasive and more accurate methods for diagnosing and monitoring these conditions.

1. **Microbiological Tests:** Microbiological test kits play a crucial role in periodontal research by enumerating and identifying the microflora present in the periodontal pocket. These tests aid in diagnosing various forms of periodontal disease, assessing disease initiation and progression, and determining sites at greater risk for active destruction.

Table 2: Microbiological Tests

Tests	Omnigene	Evalusite	Perioscan
Advantages	•Quick test results provided within hours to days. •Identifies known periodontal pathogenic bacteria.	•Detects three putative periodontal pathogens (Aa, Pg, Pi). •Rapid chairside test.	•Very sensitive in detecting small quantities of pathogens. •Comparable to other diagnostic methods for detecting specific species.
Limitations	•Acceptance in the dental community has been slower than anticipated.	•Multistage test with a subjective calorimetric endpoint. •No permanent record of the result.	•Lack of quantitative data. •Cannot identify other pathogens not producing trypsin-like enzymes.
Applications	•Monitoring periodontal pathogen levels in patients. •Supporting optimal care for periodontitis patients.	•Chairside detection of periodontal pathogens.	•Assessment of oral halitosis. •Detecting three specific periodontal pathogens in subgingival plaque.
			

- **Working Principle**

  - **Omnigene:** Omnigene diagnostics developed DNA probe systems for eight periodontal pathogens. Samples of subgingival plaque are collected from patients and sent to the clinical reference laboratory. The test detects species-specific DNA probes for pathogens like Porphyromonasgingivalis, Prevotella intermedia, Actinobacillusactinomycetem-comitans, and others.
  - **Evalusite (Kodak):** Evalusite is a membrane immunoassay that detects three periodontal pathogens (Aa, Pg, Pi) using antigen-antibody reactions. A patient's plaque sample reacts with specific membrane-bound antibodies. Enzyme-labelled second antibodies and coloured enzyme substrates reveal antigen-antibody complexes.
  - **Perioscan:** PerioScan utilizes the BANA (N-benzoyl-DL-arginine-2 naphthylamide) hydrolysis reaction to detect the presence of bacterial trypsin-like proteases in subgingival plaque. This diagnostic method is designed to identify three distinct periodontal pathogens, namely T. Denticola, P. Gingivalis, and B. Forsythus.

2. **Biochemical Tests:** Within the field of periodontics, biochemical test kits serve the purpose of evaluating the gingival crevicular fluid (GCF) to detect early indications of alterations in periodontal tissues. These kits analyse various components present in the GCF, such as host-derived enzymes, inflammation mediators, and extracellular matrix elements.

- **Working Principle**

  - **Perio 2000:** Perio 2000 is a specialized periodontal probe that combines the features of a conventional "Michigan O" style probe with advanced ion-selective electrode technology. This unique amalgamation enables it to perform a range of functions, including measuring probing depths, assessing bleeding or probing, and identifying sulfides within periodontal pockets. The Perio 2000 system consists of disposable sensor tips equipped with sulfide sensors, an electronic control unit that provides real-time feedback and a probe handle with an incorporated foot switch for ease of use.

  - **Prognos-Stik:** The Prognos-Stik test is designed to identify heightened levels of MMPs (elastases) in gingival crevicular fluid (GCF). GCF, when collected on a filter paper strip containing a fluorescent indicator substrate, undergoes a reaction with elastase, resulting in a visible indicator discernible under fluorescent light. Elevated elastase levels in GCF may signify the presence of active disease sites.

  - **PerioCheck:** PerioCheck is a diagnostic tool employed to detect neutral proteases associated with collagen degradation in cases of periodontal disease. Crevicular fluid is collected on filter paper strips and then placed on a gel matrix labeled with collagen dye. The interaction between neutral proteases and the gel generates soluble dye-labeled collagen fragments, leading to the development of a blue color.

  - **PerioGard:** PerioGard operates on the principle of identifying the enzyme aspartate aminotransferase (AST) released from cells upon cell death. Elevated total AST levels in GCF have been correlated with active disease sites.

  - **PerioWatch:** PerioWatch conducts an analysis of Aspartate Amino Transferase (AST) chairside. AST facilitates the transfer of an amino group in the presence of pyridoxal phosphate, resulting in the release of inorganic sulfite. This sulfite then reacts with malachite green, leading to a noticeable colour change.

Table 3: Biochemical Tests

Test	Perio 2000	Prognos-Stik	Periocheck	Periogard	Periowatch
Advantages	•Provides real-time bacterial activity feedback for diagnosis. •Used during initial patient screening, supportive periodontal therapy, and maintenance intervals. •Aids in patient education and motivation.	•May indicate active disease sites and disease activity. •Provides insights into the severity of gingival inflammation	•Rapid chairside test for neutral proteases like elastases, proteinases, and collagenases.	•Potential marker for early periodontal tissue destruction. •Positive association with disease-active sites.	•Provides a simple method to analyze AST levels at the chairside.
Limitations	•Limited to specific parameters and may not cover all aspects of periodontal disease.	•The relationship between elastase levels and periodontal disease activity requires further clinical trials.	•The test is qualitative and not specific for specific enzymes.	•Complex procedure involving multiple steps.	•May have poor differentiation between colours.
Applications	•Assessing oral health status during patient screening. •Monitoring patients during and after routine periodontal therapy. •Educating patients and motivating them to maintain oral health.	•Monitoring disease activity and gingival inflammation	•Identifying sites with increased levels of neutral proteases associated with active periodontal disease.	•Identifying early periodontal tissue destruction and disease-active sites.	•Measuring AST levels to assess periodontal health.

Figure 9: Perio 2000

3. **Genetic Test Kits for Periodontal Disease:** Genetic test kits have emerged as valuable diagnostic aids for periodontal disease. Certain gene polymorphisms have been linked to an increased risk of initiating or progressing periodontal disease. Researchers have identified an association between the polymorphisms in genes encoding for interleukin-1α and interleukin-1β and the severity of periodontitis. Advances in genetic testing have made it possible to detect these genetic variations using chairside kits.

- **Working Principle:** The GenoType® PST® is a genetic susceptibility test that analyzes two IL-1 genes for specific variations associated with an individual's predisposition to overexpression of inflammation and their risk for periodontal disease. The test identifies two polymorphisms within the IL-1 gene cluster, namely Interleukin 1A gene, position -889, and Interleukin 1B gene, position +3953. These genes can carry different alleles, with allele 1 harbouring a cytidine (C) and allele 2 carrying a thymidine (T). Patients with both genes carrying allele 2 are more likely to experience a strong over-production of interleukin-1, leading to aggressive bone resorption.

- **Advantages**

➢ **Personalized Risk Assessment:** The GenoType® PST® test allows clinicians to evaluate an individual's specific periodontitis risk based on their genetic profile.
➢ **Early Detection:** By identifying genetic susceptibility to periodontal disease, the test enables early detection and intervention, potentially preventing severe disease progression.
➢ **Treatment Planning:** The test helps tailor individualized therapy plans for patients with aggressive and therapy-resistant periodontitis, improving treatment outcomes.
➢ **Risk Assessment for Relatives:** Testing relatives of PST®-positive patients provides valuable insights into their risk for periodontal disease, guiding preventive measures and recall intervals.

- **Limitations**

➢ **Limited Scope:** Genetic test kits like PST® focus on specific genetic markers associated with interleukin-1 overproduction, but there may be other genetic factors influencing periodontal disease that are not covered by this test.
➢ **Cost:** Genetic testing can be relatively expensive, which may limit its accessibility to some patients.

- **Applications**

  - **Individualized Therapy Planning:** The GenoType® PST® test is beneficial for patients with aggressive and therapy-resistant periodontitis, aiding in creating personalized treatment strategies.
  - **Disease Progress Assessment:** The test is valuable for patients with excessive loss of attachment and established periodontitis, helping monitor disease progression.
  - **Risk Assessment for Relatives:** Testing relatives of PST®-positive patients helps identify their risk of developing periodontal disease, leading to targeted preventive measures.

4. **Nanodiagnostics:** Nanodiagnostics, a field of nanotechnology applied to diagnostic purposes, holds great promise in advancing oral medicine by enhancing diagnostic capabilities. It involves the use of nanoscale structures and materials to improve the sensitivity, accuracy, and cost-effectiveness of diagnostic tests. Nanodiagnostics in oral medicine have the potential to revolutionize disease detection and management, providing non-invasive and highly sensitive diagnostic tools. By utilizing nanoscale structures and materials, oral healthcare can benefit from increased sensitivity, specific targeting, and multiplexing capabilities. While challenges in research complexity and cost exist, continued advancements in nanotechnology will pave the way for innovative and efficient diagnostic tools in oral medicine, ultimately improving patient outcomes and oral health.

   - **Working Principle:** Nanodiagnostics in oral medicine rely on nanomaterials, such as quantum dots, gold nanoparticles, and nanoscale cantilevers. These nanoscale structures offer unique properties like high photostability, tunable emission, and precise detection capabilities. When combined with specific biomolecules, they can selectively bind to disease markers, enabling early identification of oral mucosal lesions and infectious agents.

   - **Advantages**

     - **Enhanced Sensitivity:** Nanodiagnostics can detect disease-specific biomarkers with high sensitivity, enabling early disease detection and intervention.
     - **Specific Targeting:** Nanomaterials can be functionalized to target specific oral disease markers, allowing for precise and selective detection.
     - **Multiplexing Capabilities:** Nanodiagnostics can perform multiplexed assays, simultaneously detecting multiple disease markers in a single sample, leading to efficient and comprehensive diagnostic outcomes.
     - **Non-Invasive and Patient-Friendly:** Nanodiagnostics in oral medicine can offer non-invasive and patient-friendly diagnostic tests, reducing discomfort and stress for patients.

   - **Limitations**

     - **Research Complexity:** Developing nanotechnology-based diagnostic tools requires significant research and development to optimize their performance and safety.
     - **Cost:** Implementing Nanodiagnostics may initially involve higher costs due to specialized equipment and materials.

- **Technical Expertise:** Nanodiagnostics may require skilled professionals with expertise in nanotechnology and diagnostic techniques.

- **Applications**

  - Oral Cancer Detection: Nanodiagnostics can help in the early cancer detection by identifying specific biomarkers associated with premalignant and malignant lesions.
  - Infectious Disease Detection: Nanotechnology can be used to detect infectious agents in oral mucosal samples, facilitating the diagnosis and management of oral infections.
  - Nanoscale Imaging: Nanodiagnostics can enable high-resolution imaging of oral tissues and cells, providing valuable insights into disease pathology.
  - Point-of-Care Diagnostics: The development of portable Nanodiagnostics devices could lead to point-of-care testing, allowing for rapid and accurate diagnostics in dental clinics and remote areas.

V. CONCLUSION

Advances in Detection of Oral Lesions have explored various cutting-edge techniques and technologies that have revolutionized the field of oral healthcare. From chemiluminescence to optical spectroscopy, brush biopsy, and salivary genomics and proteomics biomarkers, these advancements have significantly improved the accuracy and efficiency of detecting oral lesions, potentially aiding in early diagnosis and improved treatment outcomes. The integration of these advanced detection methods promises to reshape the future of oral healthcare, enhancing the overall patient experience and improving oral health outcomes. As technology continues to evolve, these techniques will likely play a pivotal role in transforming the way oral lesions, caries, and periodontal diseases are diagnosed and managed, ultimately promoting better oral health and overall well-being. Embracing these advancements and fostering on-going research in this domain will further accelerate progress, paving the way for a brighter and healthier future in dentistry.

REFERENCES

[1] Swinson, B., Jerjes, W., El-Maaytah, M., Norris, P., & Hopper, C. "Optical Techniques in Diagnosis of Head and Neck Malignancy." *Oral Oncology*, vol. 42, no. 3, 2006, pp. 221-228, doi:10.1016/j.oraloncology.2005.05.001.

[2] Kumar, Puneet, and ChandniBatra. "Modern Advances in Oral Diagnostic Medicine." *International Journal of Food and Nutritional Sciences*, vol. 11, no. 11, Nov 2022, p. 1271, ISSN 2319-1775. Online ISSN 2320-7876.

[3] Shashidara, Raju et al. "Chemiluminescence: A Diagnostic Adjunct in Oral Precancer and Cancer: A Review." *Journal of Cancer Research and Therapeutics*, vol. 10, no. 3, 2014, pp. 487-491, doi:10.4103/0973-1482.138215.

[4] Vashisht, Neha et al. "Chemiluminescence and Toluidine Blue as Diagnostic Tools for Detecting Early Stages of Oral Cancer: An In Vivo Study." *Journal of Clinical and Diagnostic Research (JCDR)*, vol. 8, no. 4, 2014, pp. ZC35-38, doi:10.7860/JCDR/2014/7746.4259.

[5] Cicciù, Marco, et al. "Early Diagnosis of Oral and Potentially Oral Malignant Lesions: A Systematic Review on the VELscope® Fluorescence Method." *Dentistry Journal*, vol. 7, 2019, p. 93, doi:10.3390/dj7030093.

[6] Bhosale, Satish, and Tarun Vyas. "Application of Oral CDx Brush Biopsy in Oral Cancer Detection." *Journal of Dental Dental and Practice*, July 2019.

[7] Dagli, A. F., Sahin, N., Bozdag, Z., et al. "Cytological and Cytomorphometric Characteristics of Buccal Mucosa Cells from Smokeless Tobacco Users." *Diagnostic Cytopathology*, vol. 45, 2017, pp. 976-982, doi:10.1002/dc.23803.

[8] Shah, Franky D et al. "A Review on Salivary Genomics and Proteomics Biomarkers in Oral Cancer." *Indian Journal of Clinical Biochemistry (IJCB)*, vol. 26, no. 4, 2011, pp. 326-334, doi:10.1007/s12291-011-0149-8.

[9] Woo, Kwon Yang, et al. "Application of Proteomics in Cancer: Recent Trends and Approaches for Biomarkers Discovery." *Frontiers in Medicine*, vol. 8, 2021, doi:10.3389/fmed.2021.747333.

[10] Lee, Jae-Hong et al. "Detection and Diagnosis of Dental Caries Using a Deep Learning-Based Convolutional Neural Network Algorithm." *Journal of Dentistry*, vol. 77, 2018, pp. 106-111, doi:10.1016/j.jdent.2018.07.015.

[11] Strassler, Howard E. and Mark L. Pitel. "Using Fiber-Optic Transillumination as a Diagnostic Aid in Dental Practice." *Compendium*, vol. 35, no. 2, Feb. 2014.

[12] Irani, Soussan. "Emerging Insights into the Biology of Metastasis: A Review Article." *Iranian Journal of Basic Medical Sciences*, vol. 22, 2019, pp. 833-847, doi:10.22038/ijbms.2019.32786.7839.

[13] Yılmaz, Hülya, and Sultan Keles. "Recent Methods for Diagnosis of Dental Caries in Dentistry." *Meandros Medical and Dental Journal*, vol. 19, 2017.

[14] Pretty, I.A. & Ellwood, R.P.. "The Caries Continuum: Opportunities to Detect, Treat and Monitor the Re-mineralization of Early Caries Lesions." *Journal of Dentistry*, vol. 41, 2013, pp. S12-S21, doi:10.1016/j.jdent.2010.04.003.

[15] Costa, Ana Maria et al. "Use of Diagnodent for Diagnosis of Non-cavitated Occlusal Dentin Caries." *Journal of Applied Oral Science (revista FOB)*, vol. 16, no. 1, 2008, pp. 18-23, doi:10.1590/s1678-77572008000100005.

[16] Yoon, Richard, and Jed Best. "Advances in Pediatric Dentistry." *Dental Clinics of North America*, vol. 55, 2011, pp. 419-32, vii, doi:10.1016/j.cden.2011.02.004.

[17] Lee, Jae-Hong, et al. "Detection and Diagnosis of Dental Caries Using a Deep Learning-Based Convolutional Neural Network Algorithm." *Journal of Dentistry*, 2018.

[18] Pitts, Nigel et al. "Diagnostic Accuracy of an Optimized AC Impedance Device to Aid Caries Detection and Monitoring." *Caries Research*, vol. 42, 2008, p. 185.

[19] Pajnigara, Natasha G., et al. "Chairside Diagnostic Kits in Periodontics." *International Dental Journal of Student's Research*, vol. 4, no. 1, April 2016, pp. 26-30.

[20] Mani, Amit, et al. "Diagnostic Kits: An Aid to Periodontal Diagnosis." *Journal of Dental Research and Review*, vol. 3, 2016, pp. 107, doi:10.4103/2348-2915.194837.

[21] Ivaturi, Meghana Sri Sai, et al. "Advanced Chairside Diagnostic Aids for Periodontal Diagnosis - A Review." *Journal of Clinical and Diagnostic Research*, vol. 15, no. 9, September 2021, pp. ZE17-ZE22, DOI: 10.7860/JCDR/2021/50417.15407.

[22] Malagi, Sachin. "Chairside Diagnostic Test Kits in Periodontics - A Review." *Dental News*, 02 Nov. 2012, https://dentalnews-articles.blogspot.com/2012/11/chairside-diagnostic-test-kits-in.html#more.

[23] Urban, D., &Mincik, J. "Monozygotic Twins with Idiopathic Internal Root Resorption: A Case Report." *Australian Endodontic Journal*, vol. 36, no. 2, 2010, pp. 79–82, doi:10.1111/j.1747-4477.2010.00223.x.

[24] Walther, Kay-Arne et al. "The Role of Polymorphisms at the Interleukin-1, Interleukin-4, GATA-3 and Cyclooxygenase-2 Genes in Non-Surgical Periodontal Therapy." *International Journal of Molecular Sciences*, vol. 23, no. 13, 30 Jun. 2022, doi:10.3390/ijms23137266.

[25] Dumitrescu, Alexandrina, and Junya Kobayashi. "Modifying Disease Genes in Relation to Periodontitis." In *Title of the Book*, edited by Editor's Name(s), 1st ed., 2010, pp. 31-112. ISBN 978-3-642-00679-1. doi:10.1007/978-3-642-00680-7_4.

[26] Chapple, Iain L C et al. "Periodontal Health and Gingival Diseases and Conditions on an Intact and a Reduced Periodontium: Consensus Report of Workgroup 1 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions." *Journal of Clinical Periodontology*, vol. 45, Suppl 20, 2018, pp. S68-S77, doi:10.1111/jcpe.12940.

[27] George, Saranya. "Nanotechnology in Dentistry- A Review." *IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)*, vol. 16, no. 1, Ver. VII, January 2017, pp. 90-95, DOI: 10.9790/0853-1601079095, www.iosrjournals.org.

