Review Article

Advanced Chairside Diagnostic Aids

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Abstract

Periodontal diseases are complex, multifactorial conditions that require precise diagnosis for effective treatment and management. Traditional diagnostic methods, including clinical probing and radiographic assessment, have limitations in detecting early disease progression and providing real-time data. Advances in diagnostic aids have revolutionized periodontology, enhancing accuracy, reproducibility, and early disease detection. Novel technologies, such as computer-assisted periodontal probes, digital imaging, biomarkers, molecular diagnostics, and artificial intelligence-driven tools offer superior diagnostic capabilities. Cone-beam computed tomography, optical coherence tomography, and fluorescence-based detection methods provide detailed visualization of periodontal structures. Salivary diagnostics and genetic markers enable non-invasive, patient-specific disease prediction and monitoring. This review explores the latest advancements in periodontal diagnostic aids, highlighting their clinical applications, benefits, and future potential in personalized periodontal care.

Keywords: Biochemical tests, Chairside diagnostic kits, Genetic tests, Microbiological tests, Periodontal disease.

Introduction

Microbial dysbiosis and the host immune response are the two main causes of the varied group of chronic mouth inflammatory illnesses known as periodontal diseases. Periodontal diseases are the eleventh most common disease worldwide, according to a recent assessment on the burden of disease worldwide.[1] To accurately diagnose both stage and grade, various diagnostic studies at the chairside, frequently tooth-by-tooth is required due to the diverse clinical manifestations of periodontal diseases. For a more thorough diagnosis, a number of risk factors that could affect the illness are also methodically investigated, including genetic vulnerability, smoking, diabetes, obesity, and stress.[2]

Nowadays, the primary sources of information for a periodontal diagnosis are patient's medical and dental history, radiographs, histological analysis, and a thorough clinical examination. Traditional clinical methods for diagnosing periodontal conditions include assessing bleeding on probing, probing pocket depth, loss in clinical attachment level, and the periodontal index.[3]

The identification of risk groups and the complex nature of periodontal pathology have highlighted the importance of objective testing in the initial diagnosis of periodontal patients.[4] However, microbial etiology and diagnostics play a crucial role in confirming a definitive diagnosis. Therefore, microbiological analysis, combined with clinical monitoring, improves the quality of treatment and provides a valuable reference for strategic therapy.[5]

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Discussion

This review article includes the following: (1) a summary of the current trends in chair-side diagnostic-kit, with a focus on the off-the-shelf probing tools for assessing the gingival health; (2) a brief introduction to the chair-side biomarker assessment kits; (3) a summary of the future of in-office diagnostics.

Probes as assessment tool

Assessing attachment loss has been an essential factor in determining the stage and grade of the disease since prolonged periodontal inflammation can result in the loss of the supporting periodontium. It is also a reliable indicator of future tissue degradation and, consequently, the progression of the disease.[6] The sensitivity and repeatability of readings are influenced by a number of variables, including probe-

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tip size, probe insertion angle, probing pressure, probe calibration accuracy, and the level of inflammation in the underlying periodontal tissues. Clinical pocket depth measurements taken with periodontal probes may not always accurately represent the true depth of the pocket, as the probe can pass through the junctional epithelium and reach the underlying connective tissue in an inflamed gingival sulcus.[7]

To overcome this, there has been an advancement in probe from first generation (manual probe) to fifth generation which are sophisticated probes that combine 3D imaging, laser technology, and artificial intelligence for improved diagnostics.[8]

The DetecTar (NEKS Technologies) uses spectro-optical analysis to detect calculus through an optical fiber that converts signals into electrical data. It has a probe similar to traditional periodontal probes (0.45 mm diameter) and a cordless handpiece option. The perioscopy (Zest Dental Solutions) is a periodontal endoscope that magnifies the root surface (up to ×48) for precise calculus detection. The Diagnodent (KaVo Kerr) is a pen-shaped probe that detects autofluorescent signals from calculus lesions, displaying intensity levels digitally.[9]

Diagnosis with the imaging tools

Radiographs

Two-dimensional (2D) oral radiography is one of the most widely used conventional method for the diagnosis of periodontal disease, but due to its shortcomings, it was replaced by 3D radiography, including cone-beam computed tomography. The main goals are to assess alveolar bone levels, bone destruction patterns, marginal shape, and the extent of bone loss.[10]

Intraoral scanners

In dentistry, intraoral scanners were created to take the role of traditional dental impressions. By detecting the color variation in soft tissue, it can also evaluate tissue regeneration or gingival health. Taking into account that keratinized and non-keratinized tissues differ in color, the dimensions of the keratinized mucosa can be assessed.[11] A 3D intraoral scanner with an LED light source that can recognize color was employed in a study by Lee *et al*., as a toll to assess the width of keratinized tissue more precisely than a periodontal probe.[12]

Chairside periodontal tests

Chairside periodontal test kits are classified into the following categories:

- Microbiological test kits - Used to detect periodontal pathogens
- Biochemical test kits - Measure biomarkers associated with periodontal disease
- Genetic test kits - Assess genetic susceptibility to periodontal conditions.

Microbiological tests

An ideal periodontal diagnostic test should be:

- Sensitive, quantitative, specific, and reproducible
- Simple to perform, rapid, non-invasive, and chairside-compatible
- Versatile in sample handling and cost-effective
- Require minimal, robust instrumentation.[13]

Microbiological test kits

Microbiological tests can aid in diagnosing various types of periodontal conditions, indicate the onset and progression of these conditions, and identify periodontal sites that are more susceptible to active destruction. The bacteriological assessments (microscopy, evalusite, omnigene, culture, and affirm DP) primarily focus on spirochetes, detecting Aggregatibacter actinomycetemcomitans (Aa), Porphyromonas gingivalis (Pg), and Provetella intermedia (Pi). In addition, microbial tests can be utilized to track the effectiveness of periodontal treatments aimed at controlling or eliminating pathogenic organisms associated with periodontal disease.[14]

Omnigene

Omnigene (Figure 1) is a DNA probe system designed for identifying various subgingival bacteria known to be associated with periodontitis. A paper point sample of sub-gingival plaque is collected, placed in the provided container, and then sent to the company for analysis. Probes for available for detecting Aa, Pg, Pi, *Fusobacterium nucleatum*, *Campylobacter rectus*, *Treponema denticola*, and *Eikenella corrodens*. Results are delivered within a very short timeframe, ranging from a few hours to a few days.[15]

Evalusite

Evalusite is a diagnostic kit that uses a unique membrane-based enzyme immunoassay to identify three potential periodontopathogens: Aa, Pg, and Pi.[16] A sample is collected from the sub-gingival region using paper points and placed into a specified sample tube. The eluent is then introduced to the kit,

Figure 1: Omnigene

which utilizes a sandwich-type enzyme-linked immunosorbent assay (ELISA). A pink spot appears if the target organism is detected.[17]

PerioScan®

Perioscan (Figure 2) is a diagnostic test that detects trypsin-like proteases of bacteria in plaque using the BANA-hydrolysis reaction. This reaction occurs in bacteria, such as *P. gingivalis*, *T. denticola*, *T. forsythia,* and some *Capnocytophaga* strains. BANA, a substrate linked to beta-naphthylamine (p-NA), is broken down by these enzymes, releasing p-NA, which then reacts with dyes to produce a color change. The test employs a sandwich-type ELISA, with the appearance of a pink spot signaling the presence of the target bacteria.[18]

The main limitations of the tests are:

1. It assumes three specific organisms cause the disease
2. It involves multiple stages
3. Results depend on subjective color assessment
4. There is no permanent record of outcomes.[19]

The BANA test detects specific subgingival plaque bacteria by reacting with "Fast-Black" dye, turning blue-black after 15 min at 55°C if positive. While sensitivity has improved, limitations include reliance on plaque collection, qualitative color evaluation, and the assumption that detected bacteria indicate active disease.[20] False positives may occur in healthy sites or persist post-treatment. In addition, microbiological tests may overlook bacterial interactions, making single-species detection overly specialized.[19]

Perio 2000

Numerous pathogenic bacteria, including *P. gingivalis*, *P. intermedia*, and *T. forsythia*, degrade serum proteins cysteine and methionine to create sulfates and consequently high quantities of volatile sulfide compounds (VSCs). These VSCs can directly break down periodontal structures, which exacerbate periodontitis. As a result, their assessment can reveal the subgingival microbial load. The purpose of the Perio 2000 system is to digitally display the sulfide level at every location. In summary, the probe tip needs to be inserted subgingivally at peak or hold operating mode after being hydrated with the manufacturer's sterile wash solution. Once the reading is affirmative, the tip is cleaned and put again in another subgingival location.[21]

Biochemical test kits

Gingival crevicular fluid (GCF) is analyzed using biochemical test kits in periodontics. Since this fluid is made from periodontal tissues, analyzing its components – such as extracellular matrix components, inflammatory mediators, and host-derived enzymes – may reveal changes early.

Prognos-stik

In 1993, this test kit began to be marketed. It finds that the GCF contains higher amounts of matrix metalloproteinases (MMPs), including elastases. A known quantity of buffered elastase substrate that has been marked with a fluorescent indicator is used to permeate the filter paper strip onto which the GCF is collected. Under fluorescent light, the test strip's elastase cleaves the substrate over the course of 4–6 min, releasing the indicator. When polymorphonuclear leucocytes aggregate at gingival inflammatory sites, their lysosomes release elastase. Accordingly, high elastase levels in GCF might be a sign of active disease areas.[22]

Periocheck

Periocheck (Figure 3), a Food and Drug Administration -approved in the US, is the fastest chairside test for neutral proteases, with enzyme levels increasing in gingivitis and periodontitis. The test uses a collagen-dye complex, which releases a blue color when broken down by proteases. While it detects enzymes, such as collagenases, proteinases, and elastases, it does not specifically identify polymorphonuclear leukocytes collagenase and is purely qualitative. A key limitation is the inability to test interproximal areas due to saliva contamination.[23]

PerioGard

Aspartate aminotransferase (AST) is an enzyme released during cell death, making it a potential marker for early periodontal tissue destruction.[24] The PerioGard assay measures AST in (GCF) by collecting a sample on a filter paper strip,

Figure 2: Perioscan

Figure 3: Periocheck

mixing it with a substrate mixture containing 1-aspartic and α-keto-gluteric acid, and detecting glutamate and oxaloacetate production. A dye-like quick red creates a color change proportional to AST activity. However, the test is complex, involving multiple steps, and has poor color differentiation.[25]

Pocket watch

The pocket watch is a simple chairside test for AST analysis. It detects AST activity by catalyzing a reaction that releases sulfite ions, which then decolorize malachite green (MG), revealing pink rhodamine B dye. The rate of MG color change correlates with AST concentration. However, extracellular matrix components in GCF from diseased pockets may release sulfide ions, potentially affecting results. In summary, the AST activity measured by pocket watch indicates the degree of the damaging pockets in addition to cell death.[26]

Periosafe

PerioSafe, a MMP-8 oral fluid point-of-care immunotest, is designed to identify and screen sites and patients with chronic and early-stage periodontitis. It predicts progression of disease, differentiates active disease sites, and can be used to monitor treatment efficacy, response to medication, and periodontal maintenance. The PerioSafe, a MMP-8 test, has it exhibited a sensitivity of 76.5% and a specificity of 96.7% for detecting >2 sites with deepened pockets. It has been independently and internationally validated across various countries, including Africa, Europe, and the USA, consistently proving its effectiveness in distinguishing between periodontal health and disease.[27]

MMP-8 dipstick test

This test uses immunochromatography with monoclonal antibodies targeting MMP-8 isotopes to detect *C. rectus*, *P. gingivalis*, and *F. nucleatum*. It addresses challenges in microbial testing, such as variability across laboratories and sensitivity to small-volume samples, such as GCF.[28] The lateral flow sandwich immunoassay, using MoAB 8706 and MoAB 8708 conjugated to latex, provides a rapid, sensitive method for assessing MMP-8 levels. A positive result indicates increased collagenolytic activity, signaling a higher risk of peri-implant damage and alveolar bone loss, commonly associated with inflammatory conditions, such as periodontitis and cardiovascular diseases.[29]

Genetic test kits

The development or progression of periodontal disease is thought to be influenced by a number of gene polymorphisms. Kornman *et al*., discovered in 1997 that a variation in the genes that encode interleukin-1α and interleukin-1β was linked to more severe cases of periodontitis.

Although genetic polymorphism identification is challenging, chairside kits are now available to detect it.[30]

Periodontal susceptibility test (PST®) genetic susceptibility test

The first and only genetic test that looks for differences in the genes of two interleukins (IL-1α and IL-1β) is the (PST®). Genetic sensitivity to IL-1 may result in an earlier or more severe disease rather than starting or causing it. Even before the age of 60, people at risk for severe periodontal disease can be identified by using the IL-1 genetic test to distinguish between specific IL-1 genotypes linked to distinct inflammatory responses.

In clinical settings, PST® is utilized in:

- New periodontal patients to guide treatment plans
- Patients needing extensive therapy to assess prognosis and improve outcomes
- Smokers as motivation to quit
- Maintenance of patients to determine recall intervals and adherence
- Early-stage cases to evaluate the need for specialist referral.[31]

The accuracy of the initial diagnosis is critical to the effectiveness of any treatment in periodontology. Most cases of chronic periodontitis may currently be effectively treated with current diagnostic techniques; however, it is obviously preferable to be able to identify "active disease" as it develops rather than months later. Numerous chairside diagnostic test kits for biochemistry have been put on the market. The recently released chairside assays for bacterial and host indicators of periodontal disease present opportunities that would enable targeted site surveillance. The dentist must, however, make sure that the use of such tests will benefit the patients in terms of the time and financial costs as well as the value of the diagnostic data acquired. The validation of new periodontal diagnostic methods must be compared against established gold standards of the disease, such as alveolar bone levels and clinical attachment levels, in large population studies.

Conclusion

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The dentist must, however, make sure that the use of such tests will benefit the patients in terms of the time and financial costs as well as the value of the diagnostic data acquired. Validation of novel periodontal diagnostics need to be benchmarked with existing gold standards of the disease, such as alveolar bone levels and clinical attachment levels, in large populations.

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