Recent advances in clinical periodontal diagnosis and periodontal treatment procedures: A brief review

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Abstract

Periodontal disease, one of the most common oral diseases, is characterized by gingival inflammation and periodontal tissue destruction. The periodontal disease phase is discontinuous, with periods of exacerbation and remission, making diagnosis, and prevention difficult for clinicians. Newer risk factors have been identified, and environmental and genetic factors may have influenced the pattern of disease. This review article highlights about the recent advances used in the diagnosing and treating the disease and throws light on the various available points of care diagnostic devices.

Keywords:
Nanotechnology, Periodontal diagnosis,
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Introduction

Periodontology is a subject that deals with the scientific research of gingiva, alveolar bone, periodontal ligament (PDL), and root cement in the health and disease state of the periodontium. Its history comprises many failures and advances, with expansive conceptions regarding periodontal pathobiology and treatment.

Periodontal disease is a global predicament and includes an ancient spectrum of illnesses, ranging from mild gingivitis to severe periodontitis. Periodontal diseases have been present for a long time unlike caries which is a more modern issue, therefore, not a derivation of the contemporary world. Periodontal pathology was discovered in human specimens during the Middle Pleistocene stage, and the disease manifested itself as ante mortem loss of alveolar bone. Occasionally, alveolar bone resorption was discovered in the 640–735,000-year-old Mauer mandible (Homo heidelbergensis) in Germany, and in a 169–191,000-year-old such a mandible was again excavated at the Bau de l’Aubesier, Vaucluse, France. These results have shown the hypothesis that periodontal conditions have afflicted mankind including their phylogenetic ancestry since ancient time.[1]

Periodontitis manifests as an inflammation of teeth such as PDL, gingiva, and alveolar bone caused due to oral microbiota dysbiosis. The subgingival microbiota changes from a predominant Gram-positive to a predominant Gram-negative species of bacteria during pathogenesis of periodontal disease. Various bacterial pathogens, host immune responses, and mechanisms involved have been characterized in depth by genetic and molecular studies, resulting in periodontal tissue damage.[2]

In the 1996 World Workshop in Periodontics, Actinobacillus actinomycetemcomitans, Porphyromonas gingivalis, and Tannerella forsythia were delegated as the main infectious agents giving rise to periodontal diseases. The resolution was built on a “weight of evidence” appraisal that inspect components such as relationship of the disease with the species, eradication of suspected species causing a halt on disease development, virulence factors of the species conceivably related to disease pathogenesis, antibody response by the host against the species during infection, outcome of the species in experimental animal model systems and possibility of disease continuation in individuals or sites bearing the species at high levels. After that meeting, researches have increased the connections of periodontal disease with the given three species.[3]

Periodontal disease is estimated to affect 750,847 million people worldwide, according to the 2016 global burden of disease
report, which is almost half the global population, resulting in it being the 11th most prevalent human disease. The figure is much higher than systemic disease such as diabetes and if one contemplates their close clinical relationship to periodontal disease, the prevention and treatment of this inflammatory disease, must be given utmost importance from a health policy viewpoint.[4]

In the past scenario, the main problem faced by many clinicians is precise diagnosis of periodontal disease. Usually, conventional clinical measurements, that is, probing depth, loss of attachments, presence of adequate plaque and calculus is the way for diagnosis and classification of the periodontal disease.[5,6] However, the conventional methods are only able to indicate antecedent periodontal disease, instead of current activity and also fare poorly in discerning early stages of the disease, and ascertaining treatment outcomes. Hence, researcher have started focusing on designing supplementary kits that can be used in early detection of the disease so, the disease can be treated with minimum or non-invasive therapy which has a much higher acceptance rate by patients. Thus, several diagnostics kits are currently being marketed as an adjunct for the purpose of basic job, that is, dividing diseased from non-diseased individuals and detection of areas or individual with developing periodontitis and, also helping the clinician in regulating patient specific recall interval for maintenance treatment.[6,7] The diagnostic kits will also be beneficiary for both patients and clinicians by diagnosing active disease.

**Diagnostic AIDS in Periodontics**

The diagnostic kits can be grouped into microbiological, biochemical, and genetic test to overcome some of the limitations of conventional methods.

**Microbiological test kits**

The microbiological tests can potentially reinforce the diagnosis of different types of periodontal disease, and help in measuring the initiation and progression of the disease as well as establishing sites which are more vulnerable to destructions [Flow chart 1].[8]

**Biochemical test kits**

The kits inspect the gingival crevicular fluid (GCF), a derivative from the periodontium to analyze its constituents which may give some indications of early changes [Flow chart 2].[6]

**Genetic test kits**

Several gene polymorphisms such as genes encoding for inflammatory cytokines, namely, interleukin (IL)-1α and IL-1β are found to be risk factors resulting in the development of periodontal disease. Hence, few chair-side kits are designed for detection of the same [Flow chart 3].[8]

However, these marketed diagnostic kits still require a fine tuning for successful incorporation in regular dental practices. With the advent in the field of dental science research and technology, a bright future awaits in which conventional methods will slowly transition to more advanced precise diagnostic kits. These kits will help in initial diagnosis and also enhance the acceptance rate of patients with regard to periodontal treatment plan.[8] Through these kits, clinicians can also educate and motivate even the most sceptical patients by providing evidence of presence of periodontal disease activity.

After successfully diagnosing the presence of periodontal disease, another dilemma arises in the form of mapping out the exact boundaries of the periodontal pockets. At present, researcher is trying to tackle this Achilles heels by generating digitally accurate 3-D replica of the periodontal pockets. These details are important in planning for therapy and assessing the response to the periodontal therapy. A 3-D augmentation of the precise and duplicate measurements of the periodontal pockets will be a great addition in greatly improving the treatment planning as well as determining the seriousness of the periodontal disease [Flowchart 4].[6] Some of these methods includes periodontal pocket cone-beam computed tomography (CBCT)-based imaging using radio-opaque contrast agents, Optical coherent tomography (OCT), photoacoustic (PA) imaging tomography, endoscopic capillaryscopy, and magnetic resonance imaging [Table 1].[9]

Hence, detailed 3-D measurements should be augmented along with probing, as it not only increases the success rate of treatment but can also help in giving awareness to the patients about the periodontal burden inflicted by the disease.[9-11] The many methods introduced still have many flaws, even though some studies have shown success in *in vitro* research; however, more in-depth clinical trials are significantly necessary for it to be clinically applicable for day-to-day dental practices.

**Adjuncts of Conventional Periodontal Therapy**

From the very beginning, main objective of periodontal disease therapy is removal of etiological factors, that is, plaque and calculus with procedures such as scaling and root planning, and till date, these procedures remains the gold standard for any periodontal therapy.[12] Nevertheless, with the progression of dental science, many supplemental technologies and approaches have been developed over the years to aid in the treatment of periodontal disease namely-

**Lasers**

In 1960, the first laser was introduced and since then, dental researchers have been studying their prospective and, finally in 1990, Nd:YAG laser was successfully built specifically for use in dental practices and different types of lasers soon followed suit after getting FDA clearance. It was found that the Er:YAG laser assisted periodontal therapy showed promises in greatly improving mild-to-moderate periodontal pockets without the need of surgical intervention. It is available as Waterlase™ commercially.[12]
**Photodynamic therapy**

It works on the principle in which photosensitizer stick to the cell target and gets activated in the presence of oxygen by appropriate light wavelength which results in the production of free radicals and singlet oxygen, which are noxious to some cells and microorganisms.

Photodynamic therapy can be used with scaling and root planning as supplementary for betterment of clinical and microbiological parameters.\(^{(13)}\)

**Ozone therapy**

Being a strong oxidizer, it can kill almost any microorganism including parasites by anti-hypoxic effect, resulting in reduction of inflammatory processes, with no dangerous side effects.\(^{(14)}\)

**Table 1:** Advantages and disadvantages of periodontal pocket imaging techniques

| Periodontal pocket imaging technologies | Advantages | Disadvantages |
|----------------------------------------|------------|--------------|
| X-ray-based imaging using radio-opaque contrast agents | • High resolution | • Ionizing radiation |
| | • Lower radiation exposure | • Metallic image artifacts |
| | • Fast scanning | |
| | • Broad application | |
| | • CBCT widely available and routinely used | |
| OCT | • Non-ionizing radiation | • Deep tissue imaging limited by light waves scattering |
| | • High tissue contrast | |
| | • High resolution | |
| PA imaging | • Non-ionizing radiation | • ~5 cm tissue penetration |
| | • High resolution deep tissue imaging versus OCT | • Poor penetration of gas cavities |
| | • Higher contrast versus ultrasound imaging | • Thick bones attenuate and distort signals |
| | • Faster scanning versus MRI | |
| Endoscopic capillaroscopy | • Non-ionizing radiation | • Not clear if pocket depths, area or volumes possible |
| | • Image pocket through microcirculation | |
| Magnetic resonance imaging | • Non-ionizing radiation | • Only soft-tissue imaging and low resolution |
| | • Soft and hard tissue imaging with short echo time MRI generations | • Long scanning time |
| | | • Short echo time MRI systems not broadly available |
| | | • Not clear if new MRI can image periodontal pockets |

OCT: Optical coherent tomography, PA: Photoacoustic, CBCT: Cone-beam computed tomography, MRI: Magnetic resonance imaging

**Periodontal trays**

In this, chemical non-invasive therapy is combined with conventional mechanical methods to help specific patients in managing biofilm growth in periodontal pockets such as local administration of hydrogen peroxide gel to reduce pocket depth and bleeding.\(^{(12)}\)

**Nanotechnology**

It has taken the medical world by storm with its potential but the science is still new in the field of dentistry. It is only a matter of time before its full potential can be used in the treatment of periodontal disease.

Periodontal disease-causing bacteria can be destroyed by use of nanorobots configured with area specific knowledge without causing harm to commensal oral microflora which aid in maintaining the health of the oral cavity.\(^{(15)}\)

**Gene therapy in periodontics**

Another emerging trend in periodontology, in which local application of growth factors may encourage periodontal regeneration. Some of the approaches that have been proposed are given in Table 2. The challenge faced by these approaches is that insufficient amount of tissues is often regenerated with difficult predictability.\(^{(16)}\)

**Advances in Periodontal Regeneration and Repair**

The many strenuous studies and researches done by our predecessors has heralded a new path in non-invasive treatment of periodontal disease but the biggest challenge, that is, predictable regeneration of periodontal tissues destroyed by periodontal disease is yet to be solved. Restoring the original form and function of periodontal tissues destroyed by the disease is the desired end result of any periodontal therapy and since periodontium has high regenerating capabilities, researchers have been focused on developing techniques and materials with the same regenerating capabilities.\(^{(17)}\)

Many traditional periodontal treatments, both non-surgical and surgical have only succeeded in repairing the periodontium

**Table 2:** Various approaches of gene therapy

| Approach | Mechanism of action |
|----------|---------------------|
| Protein based | Growth and differentiation factors like TGF-β, BMP-2, 6,7,12, bFGF, PDGF, and VEGF etc., are used for periodontal regeneration |
| Cell based | The use of mesenchymal stem cells has proven to be effective in the repair of bone lesions that are too large to recover normally |
| Based on gene delivery | Gene therapy is used to promote tissue replication and resolve the short half-lives of growth factor peptides in vivo by using a vector that encodes the growth factor |

TGF-β: Transforming growth factor, BMP-2: Bone morphogenetic protein, PDGF: Platelet-derived growth factor, VEGF: Vascular endothelial growth factor
Recent advances in periodontal diagnosis and treatment procedures

but regeneration is still a farfetched dream mainly as it involves regeneration of both hard tissues, that is, bone and cementum and, soft tissues, that is, gingival and PDL. Regeneration will finally take place when all these components synchronize and unify, but there are numerous obstacles acting as rock block from achieving complete regeneration such as biological events, factors, and cells. [18]

At present, two approaches are available for periodontal regeneration, namely, guided-tissue regeneration (GTR) and tissue engineering procedure. GTR is a surgical technique for regenerating the periodontium with the objective of preventing apical growth of epithelium by placing a barrier under the gingiva hence, allowing cells to form PDL tissues and alveolar bone. This technique has been popularly used for decades by clinicians and various researches have successfully shown the benefits of the treatment such as reduction in pocket depth, increased clinical attachment level, and bone regeneration. However, like any procedures, it comes with limitations and many factors involved such as diabetes and smoking reduces its success rate. [19]

In tissue engineering procedures, new tissue formation is induced through biomimetic systems built by using stem cells, scaffolds, and bioactive molecules. Even though these procedures are promising, they are in the initial stages of development and still require significant clinical research. If researchers were able to successfully regenerate the periodontium with little or no side
effects, it will completely transform the field of periodontology and pave a way to better treatment therapy.\(^{[20]}\)

Another trend that is making head way in dentistry is 3D printing, a disruptive technology that provides an alternative pathway for manufacturing products. Many researchers are currently testing out the potential of this technology in regenerative periodontology and in one study 3D printed bioreabsorbable scaffold was used for repairing periodontal tissue in a patient suffering from aggressive periodontitis for preservation of his dentition. Thus, 3-D printing has potential in changing the future of dentistry including periodontology but the drawback is that machine and materials are expensive and requires skilled operator for proper running and maintenance.\(^{[19]}\)

A multidisciplinary approach uniting engineering, dentistry, medicine, and infectious disease specialists is essential for further advancement for bringing about homeostasis of the periodontium for optimum wound healing.

**Future of Periodontal Research**

From the above, we can see that periodontal researches are being conducted at an increasing rate to better understand and enhance the treatment of periodontal diseases. However, the frustrating part is that at the end of every clinical studies or trials, the researcher almost always concludes with the statement that further research is necessary for the said procedures or technologies to become applicable in day-to-day clinical practices. This has disheartened many of the enthusiastic younger researcher making them feel as if little or no advances have been made so far. Nevertheless, we know that the field of periodontology has made a massive progress if we took time to look back at its history.\(^{[21]}\) Compared to the past, we have a better understanding of periodontal disease, its pathophysiology and how to treat it effectively. All of this was possible only because of hard work and dedications put in by our predecessors in searching for answers through research and studies.\(^{[21]}\) Recently, a review by Shazam (2020) discussed the innovative period of diagnostics based on dental fluid, where biomarkers in GCF and saliva are introduced as possible future diagnostic tools that gives knowledge on the degree of involvement of alveolar bone and determines people receptive to bone loss. As a result, these biomarkers along with diagnosing the disease, they also help to reduce disease incidence and worsening at an early stage.\(^{[21]}\) 50 years or so in the future, the entire treatment plan and management of periodontal disease might completely take a 180\(^{\circ}\), meaning progress will always be made no matter how long it takes.

Even though research play a significantly important role, some clinical studies show limited relevance and implementing them clinically is an unrealistic idea as they play little or no role in the management of periodontal disease.\(^{[4]}\) Therefore, one thing any researcher should keep in mind and focus on is the clinical applicability of the research being performed and the benefits patients can gain from the research sooner or later.

Despite all the progress made in the treatment and diagnosis of periodontal disease, the biggest challenge faced by any clinicians is the lack of public awareness especially in a developing country like India. Many patients still have the mindset that mantra and herbs can cure bleeding gums and toothache and if these do not work, they go to a roadside quack who perform unethical procedures and as a last-ditch effort, the patients finally pay the dentist a visit. The patients will come with high expectation that they will finally be able to get the proper treatment and the clinician will try to do their best to treat the disease and sometimes even exceed their expectation but no clinician can perform a miracle. Hence, in a country like ours, future research should focus on how to increase awareness of oral health and disease, and educate the populace on a large scale. This will help in motivating the patients to seek out the right specialist for early diagnosis and management of the disease. Another important point to be noted is the close link between systemic disease such as diabetes, cardiac disease, respiratory disease, and periodontal disease. For this, the general doctor needs to closely work and communicate with the dental profession in a holistic manner to tackle these diseases together.

**Conclusion**

Curiosity is human’s nature and research helps us find answers to those baffling, unanswered questions. Results may not always be satisfactory but it will open up new possibilities and give rise to new ideas, thus, benefitting mankind.

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