

FUTURISTIC TRENDS IN PERIODONTICS

Abstract

With the advancement in medical science and digitalization, the ability to diagnose, anticipate, and treat periodontitis may be improved by a number of novel technologies that have been or are being developed. Periodontal regeneration may be possible with the use of more recent therapeutic approaches. Patients with persistent periodontal disease will benefit from the pursuit of novel or updated techniques to control the disease. More attention is being paid to the creation of more accurate and focused diagnostic tools for periodontal disorders, in addition to innovative treatments. The results of these tests will enable clinicians to assess a patient's level of disease activity and the potential for attachment loss. With the innovation of various biomarkers and diagnostic probes the disease activity can be monitored at the micro level and accordingly, the best treatment can be provided. With the newer surgical techniques, a more precise and minimally invasive surgical procedure is possible in periodontal regeneration and dental implants.

Authors

Dr. Neeraj Deshpande
M.D.S, Professor
K.M. Shah Dental College
& Hospital, Vadodara
Gujarat, India.

Dr. Aayushi Shah
Post - Graduate Student
K.M. Shah Dental College
& Hospital, Vadodara
Gujarat, India.

The field of periodontal science has greatly advanced from a diagnostic and treatment standpoint as a result of medical science and digitalization advancements. This has resulted in a radical shift in how people view periodontal disease and opened up new opportunities for both non-surgical and surgical management of the condition.

Controlling errant bacteria, reducing soft tissue inflammation, and regenerating lost alveolar bone support are the clinician's top priorities in the treatment of periodontal disease.

The following sections list the numerous innovations that have been made in the detection and treatment of periodontal disease.

I. FUTURISTIC TRENDS IN NON-SURGICAL THERAPY IN MANAGEMENT OF PERIODONTAL DISEASE

- 1. Newer Generation of Probing System:** In the field of periodontology, there have been five generations of probes introduced.

Construction on the fourth generation probe is ongoing. In order to provide a 3D image of the problem location, this probe seeks to sequentially record its position with the gingival sulcus.

The fifth generation probe is the next; these probes are non-invasive and made to produce a 3D image. The upper limit of the periodontal ligament is detected, imaged, and mapped by the ultrasonographic probe using an ultrasonic wave to indicate periodontal disease. There is ongoing research to produce an even better approach for identifying periodontal disease, such as optical coherence tomography (OCT), which was established by Huang et al in 1991 and works on the principle of coherence near infrared light.

With a resolution of 5–15 μ m and a penetration depth of 1-2 mm, it provides a real-time 3D tomographic image. For the structural investigation of periodontal tissue in pig jaws, Mota et al. used two OCT systems operating in the Fourier domain with wavelengths of 930 and 1325 nm. They found that the 1325 nm system performed better than the 930 nm system.

There are other technologies, including as endoscopic capillaroscopy, which may capture the microcirculation in the periodontal pocket.

- 2. Townsend and D'Aiuto** developed fiber-optic probes to look directly into the periodontal pocket wall and its microcirculation, as well as to evaluate changes in the number and diameter of blood vessels associated with periodontal disease.

A 950 μ m fiber-optic imaging probe that is placed into the gingival sulcus or periodontal pocket forms the system's root. Green light with a wavelength of 520 nm is utilized for illumination, and both oxygenated and deoxygenated blood may absorb it. As a result, red blood cells will appear dark against the green background of blood arteries. The authors of this study determined that capillaroscopy combined with optical fiber technology could result in high-resolution imaging of periodontal pocket microcirculation.

Another technology is photoacoustic imaging. Photoacoustic (PA) imaging combines the strong contrast of optical imaging with the high resolution of ultrasound imaging. This imaging technique is based on the PA effect, which Alexander G. Bell discovered in 1880. In PA imaging, optical radiation is absorbed by natural chromophores like as hemoglobin, melanin, and others, as well as exogenous contrast agents such as chemical dyes. This causes thermoplastic expansion, which produces acoustic (ultrasound) waves. It is possible to recognize these ultrasound waves and convert them to electric signals, which are subsequently processed for imaging.

PA imaging technology was recommended for periodontal pocket imaging and measuring as a diagnostic tool, with the added benefit of being non-invasive because it could visualize the periodontal pocket with 0.01 mm precision.

Another method that has the added benefit of monitoring volatile sulfur levels is the diamond probe. It is a plastic equipment with black bands for measuring pockets in addition to measuring the volatile sulfur concentration in the sulcus, which helps the clinician identify the disease site.

II. NEWER ADVANCES IN BIOMARKERS

1. **Biosensors:** Biosensors are devices that produce signals when they come into touch with an analyte, allowing them to detect and analyze chemical and biological responses. It is a printed sensor built inside a piece of prosthetic equipment. These tools are now being used to find peri-implant and periodontal disease biomarkers. **Mohseni et al.** identified matrix metalloproteinases (MMP-9) in 2016 utilizing a carboxymethyl dextran hydrogel sensor system with immobilized monoclonal MMP-9 antibodies.
2. In their investigation to identify matrix metalloproteinases (MMP-1, MMP-8, and MMP-9) for the diagnosis of peri-implant disorders in 2017, Ritzer et al. used diagnostic chewing gum. These authors all advocated for additional clinical studies on the application of biosensors to a larger population.
3. **Lab-on-a-chip (LOC):** The use of lab-on-a-chip (LOC) technology as a point-of-care diagnostic tool to identify biomarkers for periodontal disease. **Christodoulides et al.** developed a LOC platform based on the immunoassay idea that uses a microfluidic chip and a fluorescence-based optical system to assess three salivary biomarkers (MMP-8, IL-1b, and C-reactive protein) for the diagnosis of periodontitis.
4. **PCR chip:** A PCR chip was created to aid in the rapid diagnosis of periodontal diseases. The gadget is made up of a microfluidic cartridge containing all of the PCR chemicals and a component used to drive and regulate the working process. The fundamental component of the drive is the thermo cycling device, which is made up of six fan-shaped heating blocks. Three of the blocks are used for denaturation, annealing, and elongation, while the remaining three are utilized to rapidly vary the temperature inside the blocks. During the detection procedure, samples and PCR reagents are combined in a chip, which rotates on a heat circulator to conduct PCR. To determine the amplification, a fluorescence detector analyzes the fluorescence signal at 72 °C for each cycle. This device helps in measuring different bacterial strains in clinical study.

III. NEWER ADVANCES IN PROBIOTICS

Nisin-Based Probiotics : Recently, oral uses of a special probiotic, *Lactococcus lactis*, which produces nisin and has been used extensively in many different kinds of applications, have been investigated. Few gram-positive bacteria, such as *Lactococcus* and *Streptococcus* species, produce an antibiotic peptide known as nisin.

The Food and Drug Administration in the USA granted nisin approval in 1988 and the label "generally recognized as safe" for use in processed cheese.²

The efficacy of nisin as a mouthwash in preventing plaque accumulation and gingivitis was compared to placebo and 0.12% chlorhexidine. The results showed that using a nisin mouthwash twice daily at a concentration of 100 or 300 g/ml reduced bleeding sites and improved plaque and gingival index scores. Furthermore, the nisin mouthwash had a lower staining index score, indicating that it may be used as a maintenance rinse on a regular basis, whereas chlorhexidine left stains after use.

At concentrations ranging from 2.5 to 50 g/ml, nisin strongly reduced the planktonic growth of these harmful bacteria. The inhibitory effects grew stronger with increasing nisin concentrations up to 200 g/ml.²

1. **Nanotechnology:** The research and development of applied science at the atomic, molecular, or macromolecular levels is referred to as nanotechnology or nanoscience.
2. **Nanorobotic toothpaste :** Dentifrobots could be programmed to recognize and eliminate harmful bacteria found in tooth plaque. Dentifrobots that are 1-10 in size and 1-10 /s in speed have the advantages of being modest and affordable because they are entirely mechanical devices that would securely deactivate themselves if swallowed.
3. **Drug Delivery System with Nanotechnology:** Due to the low oral bioavailability of traditional oral formulations, new treatment approaches, such as the use of nanotechnology for drug delivery, have become available. A variety of natural and synthetic materials-based polymer-based delivery systems, including films, chips, strips, fibers, microparticles, nanofibers, and nanoparticles, have been successfully tested to transport a range of medications.⁴

Nanospheres made of a biodegradable polymer can incorporate drugs. This permits precise site drug delivery and timely drug release when the nanospheres deteriorate.³

4. **3-D Printing:** 3-d printing enables small quantities of customized goods to be manufactured for relatively inexpensive prices. Although it is now mostly used to produce prototypes and mock-ups, there are a number of interesting applications in the manufacture of replacement components, scaffolds, dental crowns, artificial limbs, and bridges.⁷

Similar to how conventional laser or inkjet printers operate, 3D printers build objects gradually from an image layer by layer utilizing powdered or liquid resin as opposed to colorful inks.

The 3D printer applies a thin layer of liquid resin on top of each layer before solidifying each layer with a computer-controlled UV laser in the desired cross section pattern. A process towards the end of it removes extra-soft resin. Due to the intricate hierarchical arrangement of periodontal tissues, periodontology necessitates multiphasic biomaterial architectures that can duplicate the structural integrity of the bone-ligament proximity.⁸

With some success, specially made polycaprolactone FDM plugs are utilized to preserve the alveolar ridge instead of deproteinized xenograft materials or particulate synthetic calcium phosphate.⁹ With the help of a prototype model of the defect created from the patient's CBCT, a tailored scaffold is 3D printed using medical-grade polycaprolactone to accommodate the patient's peri osseous defect.

5. 3-D Printing and Dental Implants: Furthermore, implants will be manufactured using three-dimensional printing. Despite the fact that the technology does not appear to be there yet, this is an intriguing concept. The ability to print dental implants would allow for the development of dental implants that are particularly tailored to patients' jaws, enhancing the likelihood of implant success.

At the absolute least, the availability of custom-angled dental implants would allow for secure implantation in situations where either a conventional dental implant or an angled implant might not have enough bone to support it.¹⁰

IV. NEWER ADVANCES IN LASERS TECHNOLOGIES IN PERIODONTAL THERAPY

- 1. Laser doppler Vibrometer :** It is used to measure tooth mobility.⁶
- 2. PeriowaveTM :** PeriowaveTM is a low-intensity laser-based photodynamic disinfection device that utilizes non-toxic dye (photosensitizer). In order to treat gingival or periodontal disease, a small amount of blue-colored photosensitizer solution is applied topically to the gums at the location where it binds to bacteria and toxins linked to the disease. Next, a low-intensity laser is guided to the area treated with the drug, causing phototoxic reactions that kill bacteria below the gingival line. The procedure is rapid and painless, taking about 60 seconds.⁶
- 3. Periodontal Waterlase MDTM :** The periodontal treatment procedures, oral surgery, endoscopy, implants, and restorative and multidisciplinary dentistry treatments are the targeted applications of Periodontal Waterlase MDTM. Er,Cr:YSGG minimally invasive surgical periodontal laser therapy, which exhibits improvements in probing depth and bleeding on probing and is often preferable to scaling and root planing due to a higher successful degree of attachment repair.⁶

4. **LAPIP** : As a variation to LANAP that can be used on infected implants, McCarthy developed the idea of LAPIP, or the "Laser-Assisted Peri-Implantitis Procedure." LAPIP promotes bone and tissue regeneration, assists in restoring diseased structures to healthy states, and, perhaps most impressively, can be administered without causing harm to an implant. Since no flap is reflected, it even provides room for potential future treatments.⁶

V. FUTURISTIC TRENDS IN SURGICAL THERAPY IN MANAGEMENT OF PERIODONTAL DISEASE

1. **Piezo Surgery** : By developing and advancing classic ultrasonic technology, Professor Vercelloti's 1988 invention of the relatively new technique known as piezo surgery provides benefits and gets around the constraints of standard apparatus in oral bone surgery.

Piezoelectricity's fundamental working theory, which Jacque and Pierre Curie discovered in the late 19th century for cutting bones, is based on ultrasonic micro vibrations.¹¹

The apparatus consists of a cutting-edge piezoelectric ultrasonic transducer powered by an ultrasonic generator capable of driving a variety of resonant cutting inserts, a hand piece, and a foot switch connected to the main unit that provides power and has holders for the hand piece and irrigation fluids.

It includes a peristaltic pump for cooling, which discharges a jet of solution from the inserts and aids in clearing debris from the cutting region. To set the power and frequency modulation, the gadget comprises a control panel with a digital display. They also feature a variety of autoclavable tool tips, known as inserts, that are coated in diamond or titanium and move thanks to tiny vibrations produced by the piezoelectric handpiece.

When compared to an oscillating saw, the cutting tool used in piezoelectric osteotomy has a relatively low amplitude, which allows for more precise cutting in clinical settings.¹³ Another benefit is that a blood-free surgical site offers a better intraoperative vision. The use of piezoelectric instruments may cause localized overheating, cavitation effects, and cooling fluid to flow serve as possible explanations for absence of blood at osteotomy site.¹⁴

VI. NEXT-GENERATION REGENERATIVE THERAPEUTICS

The development of next-generation regenerative protocols and technologies requires a thorough understanding of the physiologic growth and upkeep of the PDL and its surrounding components. The perfect regenerative therapy will meet the following regeneration standards:

- Cementoblastogenesis on the surface of the tooth root,
- Oblique PDL fiber insertion into the cementum and alveolar bone
- Presence of vital supporting bone

The control of vascularization in periodontal tissues, the possibility of microbial contamination of the defect, and masticatory pressures present during healing are the main obstacles to attaining these regenerative goals.

1. **BMP-6:** Structure-wise, BMP-6 resembles BMP 5 and 7. The differentiation of osteoblasts is accomplished by it. In a study using collagen sponge carriers and BMP-6 to treat periodontal fenestration abnormalities in rats, BMP-6-treated animals had full osseous healing after 4 weeks.¹⁵
2. **GDF-7:** A supra-alveolar periodontal lesion model was used in a pilot study to assess the ability of growth and differentiation factor-7 (GDF-7)/BMP-12 to promote PDL development. According to this study, GDF-7 has a significant potential to aid in PDL regeneration.¹⁵
3. **GDF-5:** GDF-5 (BMP-14) is another TGF-superfamily member that is important for periodontal regeneration. Primordial cartilage and developing periodontal tissues, both of which express BMP-14, are found in early limb development. GDF-5 affinities are high for Activin Type II receptors, BMPR1B, and BMPR2. Human clinical trials for intrabony defect and sinus augmentation have demonstrated its efficacy in periodontal regeneration. As MD05, Scil Technology, GmbH was working on GDF-5. Scil Technology, GmbH no longer pursues clinical development after licensing the asset to Medtronic. Recent protein engineering evidence reveals that the GDF-5 mutant BB-1 has increased osteoinductive potential in a large animal model.¹⁵
4. **Teriparatide (Forteo, Eli Lilly, Inc.):** it is a synthetic form of Human parathyroid hormone (PTH) which encourages the growth of new bone. 40 patients with periodontitis received either teriparatide or a placebo once daily for six weeks after open flap debridement in the first teriparatide clinical trial in humans for periodontal repair. Even small doses of the medication produced profound long-term benefits, improving clinical attachment and causing a better resolution of osseous abnormalities.¹⁶
5. **Exosome therapy:** Exosomes, a form of extracellular vesicle, are lipid-bound nanoparticles released by cells that carry various signaling molecules such as proteins, DNA, and RNA. Exosomes' miRNA cargo and growth factor, which are thought to represent nature's endogenous nanoparticle delivery platform, are of particular interest. Human bone marrow stromal cell-derived exosomes have recently been found to be a promising treatment to reduce tissue damage and immune cell infiltration in a preclinical rat periodontitis model. The researchers discovered enriched miRNAs associated with increased protein abundance of factors such as FGF-6, IGF-1, and interleukins: IL-1ra, IL-16, and IL-3 concentrated in exosomes, as well as negative regulation of the inflammatory response.¹⁷

VII. ROBOT-GUIDED IMPLANT PLACEMENT

YOMITM (Neocis, Miami, FL, USA) was the world's first computerized navigation robotic system to be FDA-approved in 2017 to improve the clinical accuracy of dental implant surgery.¹⁸

YOMI was able to avoid the requirement for a surgical guide designed expressly for the procedure and operator hand deviation by giving physical guidance for the drill's depth, orientation, and position. The navigation system uses vibrational feedback to build dental implant osteotomies with high predictability and precision. The YOMI system, on the other hand, is extremely expensive and still in development. Zhao developed the first automated implant placing technology in the world in 2017. Surgical operations might be carried out without the need for a dentist's assistance, and they can be changed automatically and with a great degree of autonomy¹⁹. However, there are limited validation data regarding the viability and dependability of feasibility and reliability of the implant positioning, and the robot's intelligence decisions.¹⁹

VIII. CONCLUSION

As technology and science advance, so does our understanding of periodontal disease's causation and the various components that contribute to it. This greater understanding is helpful in the development of newer periodontal treatment procedures. However, more work remains to be done in order to overcome these current constraints and develop even better technologies and materials for the future.

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