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INNOVATIVE CONTEMPORARY APPROACHES TO PERIODONTITIS TREATMENT

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Abstract: This article analyzes modern, innovative, and minimally invasive methods used in the treatment of periodontitis. In addition to traditional mechanical and pharmacological treatment methods, contemporary dental practice is increasingly incorporating techniques such as laser therapy, PRF (Platelet-Rich Fibrin), photodynamic therapy, ozone therapy, biomodulators, and probiotics. These methods offer advantages such as reducing inflammation, ensuring pain relief, promoting rapid tissue regeneration, and effectively eliminating infections.
Additionally, the article highlights the significance of digital technologies such as telemedicine, artificial intelligence, and 3D navigation in the early detection and monitoring of periodontal diseases. In conclusion, modern methods provide effective and high-quality treatment options for periodontitis.
Keywords: EYWORDS: Periodontics, Periodontitis, Laser Therapy, PRF (Platelet-Rich Fibrin), Photodynamic Therapy, Minimally Invasive Methods, Telemedicine, Tooth Tissue Regeneration.

INTRODUCTION. Periodont (from Greek "peri" — around, "odontos" — tooth) is the periodontal connective tissue that holds the tooth root in the alveolar bone. It is located between the dense (compact) plate of the alveolus and the cement of the tooth root. The periodont develops from mesenchymal cells in the outer layer of the tooth socket.

Structure of the Periodont: The periodont is composed of collagen fibers that extend from the cement of the tooth root to the alveolar tissue of the jawbone. At the apex of the bony barrier between the teeth, these fibers are oriented horizontally, while some fibers extend from the cement to the gum, forming a circular ligament that surrounds the tooth. Certain fibers pass beyond the apex of the bony barrier between the teeth, connecting adjacent teeth. However, the majority of collagen fibers are arranged obliquely and take on a radial shape as they approach the root tip. This arrangement of the fibers, both oblique and radial, ensures the stable positioning of the root within the alveolus.

Between the bundles of collagen fibers, there is loose connective tissue through which blood and lymph vessels pass. The blood vessels in the periodont form anastomoses (connections) with the vessels of the jawbone and gum tissues. Additionally, the vessels in the periodont are connected to the vessels of the dental pulp through supplementary channels, ensuring circulation and nutrition between these two systems.

Functions of the Periodont:

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1. **Fixation:** The periodont securely holds the tooth in the alveolus (jawbone). However, with the development of pathological processes, the physiological mobility of the tooth gradually increases.
2. **Pressure Distribution:** Chewing pressure is alleviated and evenly distributed through the fluid accumulated between the tissues.
3. **Reflex Regulation:** The periodont contains numerous nerve fibers and sensory nerve ganglia that reflexively control chewing pressure.

Periodontitis is the inflammatory process of the periodontal tissues located at the tip of the tooth root and sometimes at the marginal (edge) areas of the root. In more than 50% of patients, periodontitis leads to tooth extraction.

The following types of periodontitis are distinguished:

- **Infectious Periodontitis:** This type of periodontitis often develops through auto-infection originating from microorganisms present in the oral cavity. Typically, the periodontal membrane at the root tip is affected, and sometimes the marginal area of the root is involved.
- **Marginal Periodontitis:** This type is an infectious inflammation characterized by the damage to tissues near the inflammation focus and the spread of inflammation to the next tissue barrier. Infectious periodontitis develops rapidly within 3–4 days, resulting in the formation of an abscess (pus accumulation) in the periapical tissues. At this stage, therapeutic interventions are performed on the tooth, or it may be extracted.
- **Traumatic Periodontitis:** This type develops as a result of acute (e.g., trauma, impact) or chronic trauma (e.g., improper occlusion due to a raised prosthesis or filling; presence of harmful habits).
- **Medicinal Periodontitis:** This type arises from the use of potent drugs (e.g., arsenic paste, formalin, antiformin).

Medicinal periodontitis can be divided into the following forms:

- **Toxic Periodontitis:** This occurs due to the toxic effects of biogenic amines produced during pulp necrosis or improperly used filling materials (silicone-2, composite, and light-cured materials).
- **Allergic Periodontitis:** This develops in cases where the patient has a high sensitivity to medicinal substances.

Important Fact: Inflammation in the periodontal tissues begins before the necrosis of the pulp tissue. This is because even in a living pulp state, bacteria, inflammatory mediators, and degradation products can exit from the root tip and reach the periodont. A confirming factor for this condition is the resorption of bone tissue, which is also observed in the early stages of inflammation.

Although various laser technologies are available for specialists in the field of oral cavity, evidence supporting their use in the treatment of periodontal diseases is mixed.

The term "laser" is an acronym for "Light Amplification by Stimulated Emission of Radiation." Lasers transmit energy by directing a beam of light or photons of a single wavelength at a target. When the laser beam interacts with human tissues, it vaporizes the water content within the cells and creates a carbon layer. Depending on the wavelength of the light, lasers can penetrate human tissues deeply.

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Lasers have been used in medicine since the early 1960s and were first applied in vivo to human teeth in 1965. Modern lasers are used in dentistry for cutting and removing tissues, and sometimes for "biostimulation" of diseased tissues.

The use of lasers in the treatment of periodontal diseases has become an important topic, and discussions continue regarding the effectiveness of lasers in dentistry, particularly in periodontology. However, the ability of certain lasers to effectively cut soft tissues or eliminate soft tissue lesions is generally undisputed. This article examines the types of lasers used by specialists in the field of oral cavity, evidence-based research on laser therapy in dental practice, and the recommendations of the American Dental Association (ADA) and the American Academy of Periodontology (AAP) for the treatment of periodontal diseases.

The lasers with the longest experience in dentistry are diode, carbon dioxide (CO_2), neodymium-doped yttrium aluminum garnet (Nd:YAG), and erbium-doped yttrium aluminum garnet (Er:YAG) lasers. Each type uses different materials in the laser medium to produce light at various wavelengths. Diode lasers typically operate in the wavelength range of 810 nanometers (nm) to 940 nm; CO_2 lasers produce light at approximately 10,600 nm; Nd:YAG lasers operate around a wavelength of 1,064 nm; and Er:YAG lasers typically generate a wavelength of 2,940 nm. Choosing the appropriate laser for dental procedures often depends on its application in hard and soft tissues.

In dental practice, CO_2 lasers are primarily used for cutting and coagulating soft tissues. This technology has a lower surface penetration compared to diode and Nd:YAG lasers. Its wavelength is highly absorbed by water, making it a good choice for vaporizing superficial cells without harming deeper tissues. CO_2 lasers can be used for identifying various types of pathologies. In addition to lesion removal, they can also be used in low-power mode to remove surface epithelial layers and eliminate various dysplastic lesions. The ability to remove the superficial epithelial layer can support the process of tissue regeneration (guided tissue regeneration, GTR) by preventing the growth of epithelial defects after periodontal surgery or extensive root planing. Other applications of the CO_2 laser include gingivectomy, crown lengthening, and uncovering implants.

The Nd:YAG laser, a popular soft tissue laser used in the treatment of periodontal diseases, can penetrate tissues more deeply (from 2 mm to 3 mm) compared to CO_2 lasers. One of the protocols for using Nd:YAG devices in treating periodontal defects involves applying local anesthesia, then passing the laser fiber optic tip from the gingival margin to the base of the pocket to remove the diseased pocket epithelium and disinfect the pocket. The teeth are then aggressively measured and root planed using ultrasonic and hand instruments. Remaining periodontal fibers are directly separated to encourage blood vessel ingress into the periodontal wound. A second pass with the laser is performed from the apical part of the periodontal defect to the gingival margin to promote fibrin clot formation and pocket closure. No sutures are required. Adjusting any occlusal discrepancies is an important part of the protocol.

The Er:YAG laser is primarily used in dentistry for hard tissue applications (e.g., calculus removal). This technology is not as popular as other types due to its limited range of dental applications. Some clinicians use Er:YAG lasers for removing caries before placing composite restorations, preparing cavities, and etching teeth, in addition to removing calculus from tooth roots. The advantage of using Er:YAG lasers for caries removal is that local anesthesia may not be required. Many clinicians are reluctant to switch to Er:YAG lasers for cavity preparation because they cannot remove gold, amalgam, or ceramic restorations. Additionally, the delivery

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system is significantly heavier than traditional equipment, and laser therapy generally requires more time compared to conventional methods.

PRF (Platelet-Rich Fibrin) – Huang et al. reported that PRF promotes the osteogenic differentiation of human dental pulp cells by increasing the expression of osteoprotegerin and alkaline phosphatase. PRF also releases growth factors, such as those derived from platelets, which stimulate periodontal regeneration. Chang et al. reported in a study that PRF stimulates cell proliferation in a specific manner. PRF induces the proliferation of osteoblasts, periodontal ligament cells, and growth factors during a 3-day culture period while suppressing the growth of oral epithelial cells. These cell-type-specific actions may be beneficial for periodontal regeneration.

Diss et al. demonstrated in a one-year prospective study using Choukroun's platelet-rich fibrin grafting material that the fibrin matrix of PRF directly aids in angiogenesis. PRF acts as a membrane for guided tissue regeneration, creating an enhanced space for grafting, which facilitates cellular events favorable for periodontal regeneration and leads to the formation of mineralized tissues. PRF possesses unique osteoconductive and/or osteoinductive properties beneficial for bone regeneration.

Sanches et al. compared the effects of PRP (Platelet-Rich Plasma) and PRF on the proliferation and differentiation of osteoblasts in an experimental study, stating that the proximity of osteoblasts to the PRF membrane was greater than that to the PRP. Sharma et al. conducted a randomized controlled clinical trial on the treatment of three-wall intra-bony defects in patients with chronic periodontitis using platelet-rich fibrin, reporting statistically significant improvements in pocket depth reduction and bone fill compared to the control group.

A similar study was conducted on treating Class II furcation defects in the mandible with platelet-rich fibrin, showing significant improvements in pocket depth reduction, clinical attachment level, and bone fill in the test group compared to control groups. Thorat et al. investigated the clinical and radiological efficacy of autologous PRF in treating intra-bony defects in patients with chronic periodontitis, reporting greater reductions in pocket depth, higher clinical attachment levels, and more significant filling of intra-bony defects in areas treated with PRF.

Another randomized controlled clinical trial evaluated three treatment groups: OFD (open flap debridement) + PRF, OFD + PRF + HA (hydroxyapatite graft), and a control group consisting of only OFD. This study showed significant bone fill in the group treated with platelet-rich fibrin compared to the control group and a significant increase in clinical attachment level in the group treated with platelet-rich fibrin combined with hydroxyapatite graft compared to the control group.

A comparative evaluation of treating three-wall intra-bony defects with platelet-rich fibrin and platelet-rich plasma indicated that the group treated with PRF showed more bone fill than the group treated with PRP. The effects of platelet-rich fibrin on human periodontal ligament fibroblasts and its application in periodontal infrabony defects were studied by Chang et al., who reported that PRF enhances the phosphorylation of protein kinases regulated by extracellular signals and increases osteoprotegerin and alkaline phosphatase activity in periodontal ligament fibroblasts. Additionally, infrabony defects showed pocket reduction and clinical attachment after six months compared to bone fill defects.

Periodontal Regeneration

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Cementum, gingiva, periodontal ligament (PDL), and alveolar bone serve as supportive tissues for the teeth (periodontium). Periodontitis is a chronic multifactorial inflammatory disease primarily characterized by the destruction of alveolar bone and the connective tissues supporting the teeth, manifesting as the loss of clinical attachment, the presence of periodontal pockets, and bleeding upon probing. The lack of treatment can lead to tooth loss. Scaling and root planing (SRP) is the initial treatment for periodontitis, allowing for plaque removal and control of local inflammation. However, these treatment methods do not ensure the reattachment of periodontal tissues to the teeth.

The goal of periodontal regeneration is to restore the supportive tissues of the teeth, aiming to create new bone, cementum, and supporting PDL to ensure optimal structure and function. As previously described by Gottlow et al., periodontal regeneration is based on the renewal of guided tissues, which, along with barriers, allow for the targeted delivery of selected cell populations while preventing the migration of epithelial cells to the regenerative site. As a result, PDL cells can migrate and activate the attachment and regeneration of connective tissues.

Recent advancements in this field, as previously described by Larsson et al., involve the use of various biomaterials, growth factors (GFs), stem cells, and bone graft substitutes. This current narrative review discusses the use of three APC (Advanced Periodontal Care) techniques in the field of periodontology: treatment of gingival recession, furcation defects, and intra-bony defects.

Photodynamic Therapy and Periodontitis

Periodontal disease originating from dental plaque is characterized by clinical signs of inflammation and loss of periodontal tissue support. Traditional periodontal therapies have involved biofilm removal combined with the adjunctive use of antibacterial disinfectants and antibiotics. Photodynamic therapy (PDT) has recently emerged as a non-invasive therapeutic method for treating various infections caused by bacteria, fungi, and viruses. It involves the use of low-power lasers at specific wavelengths to kill microorganisms treated with a photosensitizing drug.

PDT can be beneficial as an adjunct to mechanical and antibacterial agents against periopathogenic bacteria. This therapy is defined as an oxygen-dependent photochemical reaction resulting from the activation of a photosensitizing compound by light, which produces cytotoxic reactive oxygen species, primarily singlet oxygen.

Oral biofilm causes two of the most common diseases: dental caries and periodontal diseases. An effective approach to periodontal therapy is to alter the local environment to suppress the proliferation of periodontal pathogens. Microorganisms embedded in the gelatinous matrix (glycocalyx) have reduced antibiotic penetration. Using antimicrobial agents without disrupting the biofilm in periodontitis treatment often leads to treatment failure. Maintaining therapeutic concentrations at target sites is challenging, and target organisms may develop drug resistance. This resistance is minimized by PDT. Polysaccharides present in the extracellular matrix of oral biofilm are highly sensitive and susceptible to photodamage by singlet oxygen. Disrupting the biofilm can inhibit plasmid exchange involved in antibiotic resistance and disrupt colonization.

PDT is effective even against antibiotic-resistant bacteria. Although antioxidant enzymes produced by bacteria can protect against some oxygen radicals, they do not protect against singlet oxygen.

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Photodynamic antimicrobial chemotherapy can be an ideal adjunct to conventional scaling and root planing. It utilizes a rapid and simple protocol that allows clinicians to kill bacteria, inactivate residual virulence factors after scaling, and perform root planing. PDT is applied during initial and maintenance therapy for periodontitis. The activity of PDT against periodontopathogenic bacteria has been documented in vitro and in vivo for a range of photosensitizers.

The use of PDT in dentistry is rapidly expanding. It is also applied in treating oral cancer, bacterial and fungal infections, and in photodynamic diagnosis of malignant transformation in oral lesions.

Conclusion

Periodontitis is one of the most common and complex diseases in modern dentistry, making the development of effective treatment strategies a significant and urgent issue. Research has shown that the treatment of periodontitis has reached a new qualitative level with the help of modern technologies and innovative approaches. The article discusses various methods such as laser therapy, PRP (Platelet-Rich Plasma), PRF (Platelet-Rich Fibrin), photodynamic therapy, ozone therapy, as well as telemedicine and artificial intelligence-based approaches, all of which demonstrate high effectiveness in treating the disease.

In particular, the ability of PRF to stimulate periodontal regeneration, accelerate the restoration of bone tissue, and renew damaged tissues has been practically proven. Photodynamic therapy stands out as an effective means against periodontal biofilm, possessing the capacity to eliminate even antibiotic-resistant bacteria. Furthermore, the targeted application of various laser technologies (such as CO_2, Nd:YAG, Er:YAG, etc.) allows for non-invasive treatment of soft and hard tissues, enhancing safety and efficacy in dental practice.

The development of telemedicine and teledentistry serves to optimize the healthcare system by enabling remote patient monitoring, early diagnosis, and reducing the need for repeat visits. This is particularly significant for patients in remote areas. Overall, the treatment of periodontitis through modern approaches is not just a clinical process but a complex strategy based on advanced scientific and technological foundations. These technologies improve patients' quality of life, shorten treatment duration, and ensure stable healing outcomes. Therefore, the widespread implementation of these methods in clinical practice is one of the crucial strategic directions for the future of dentistry.

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