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The Subgingival Debridement: Is Conventional Periodontal Treatment Still Considered the Cornerstone of Periodontal Therapy? : A Literature Review

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Abstract Periodontitis is a globally prevalent public health issue, ranking as the sixth most common disease worldwide, with severe forms affecting a significant portion of the global adult population. This multifactorial disease results from an imbalance between host defenses and pathogens, potentially leading to tooth loss if untreated. Conventional periodontal treatment, primarily scaling and root planing (SRP), remains the standard approach. However, advancements in periodontal therapy have led to various strategies aimed at improving traditional treatment outcomes and avoiding surgical interventions. The aim of this review is to search for relevant articles which evaluate these therapeutic modalities and discuss their efficacy. The databases of PubMed, Scopus, and EBSCO were used for the literature search. The results and conclusions found are discussed in this paper. Although new therapeutic strategies have shown promise in enhancing SRP outcomes, none have proven significantly more effective than SRP alone. High-quality, long-term studies with larger sample sizes and standardized protocols are needed to better understand the efficacy and clinical relevance of these new methods.

Keywords: *periodontitis, nonsurgical periodontal debridement, conventional periodontal treatment, subgingival debridement, scaling and root planing*

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1. Introduction

Periodontitis stands as a globally prevalent and significant public health issue, ranking as the sixth most common disease worldwide [1]. Its severe form affects nearly 19% of the global adult population [2]. In Morocco, a 2022 national survey estimated the prevalence of periodontitis at 12.3%, with aggressive periodontitis accounting for 5% of cases [3,4]. This condition is a multifactorial and progressive disease resulting from an imbalance between host defenses and pathogens, leading to the destruction of supporting tissues and potential tooth loss if left untreated [5]. Moreover, periodontal disease can be influenced by various systemic diseases and may contribute to the development or exacerbation of some systemic conditions through various mechanisms [6]. Therefore, treating periodontal disease could significantly enhance the overall systemic health of patients [6]. Furthermore, periodontal disease can have a detrimental impact on both quality of life and the healthcare system due to the high cost of oral care. In fact, the global productivity loss resulting from severe periodontitis was estimated at $54 billion annually in 2010 [7]. Given these staggering figures, it is evident that periodontitis should be a top priority for prevention and treatment.

Conventional periodontal treatment consists of scaling and root planing (SRP), typically performed with manual instruments, mechanical devices, or a combination of both, with or without the administration of antimicrobials and/or antiseptics. It represents the standard treatment and the cornerstone of periodontal therapy. Various therapeutic strategies have been proposed due to the clinical advancements in this field, aimed at enhancing the outcomes of traditional therapy and avoiding the need for surgical interventions. These strategies include modifying standard treatments, therapeutic protocols, and the development of new technologies.

The objective of this literature review is to examine the various approaches to non-surgical periodontal therapy and address the following question: "Is conventional periodontal treatment still considered the cornerstone and fundamental approach of periodontal therapy?"

2. Methodology

2.1. Search Strategy

The literature search to identify relevant articles for this review was conducted through multiple stages. Firstly, an electronic search was performed using three search engines (PubMed, Scopus, and EBSCO). We utilized four keywords derived from the MeSH terms: "Dental Scaling," "Subgingival Curettage," "Root Planing," and "Dental Polishing." Secondly, a manual search was conducted by reviewing the reference lists of selected articles to locate any relevant publications that may have been missed or not indexed in the databases.

2.2. Inclusion Criteria

The papers were selected based on the following criteria:

- Publications from 2000 to 2022.
- Publications in French, English, and Spanish.
- Studies conducted on humans.
- Randomized clinical trials and controlled clinical trials.
- Literature reviews.
- Systematic reviews and meta-analyses.
- Consensus conferences and NIH consensus conferences (National Institutes of Health).

2.3. Exclusion Criteria the Exclusion Criteria included

- Studies involving patients suffering from systemic disorders or general pathologies.
- Studies focusing on physiological states such as pregnancy, old age, or smokers.
- Publications addressing surgical periodontal approaches or the maintenance phase, and systemic or local administration of substances other than antibiotics and antiseptics.
- Publications not available in full text.
- Publications not addressing the objectives of our work.

2.4. Article Selection

After removing duplicates, all articles were individually assessed by two reviewers. A preliminary screening was conducted by reviewing the titles first and abstracts secondly to refine the selection. Subsequently, a further screening of full-text publications was carried out according to pre-determined inclusion and exclusion criteria. We collected the following information: the title, author, year of publication, journal, country, article type, sample size, follow-up duration, therapeutic approach used, and the indices and parameters assessed for each therapy.

3. Results

A total of 3435 articles were initially identified through the literature search. After removing duplicates, 1602 articles were retained. The titles of the articles led to the elimination of 1407 articles that were clearly irrelevant (articles on general pathologies or specific physiological states) or belonged to other disciplines (implantology, prosthodontics, or conservative dentistry). Out of the 195 articles initially selected, 160 were retained after reading the abstracts. Subsequently, we reviewed the full texts, eliminating 21 incomplete or unavailable articles. During this final selection, 57 relevant articles, along with 8 articles from manual research, were included, totaling 65 publications. The 82 articles not included in our results were deemed irrelevant and did not meet our inclusion criteria: studies on smokers and studies dealing with the maintenance phase (Figure 1).

Due to the heterogeneity of the results obtained, the selected articles for our work were classified according to the subjects they addressed: 17 articles on laser therapy, 12 on generalities, 13 on manual instrumentation, 9 on air-polishing, and 7 each on full mouth disinfection and photodynamic therapy.

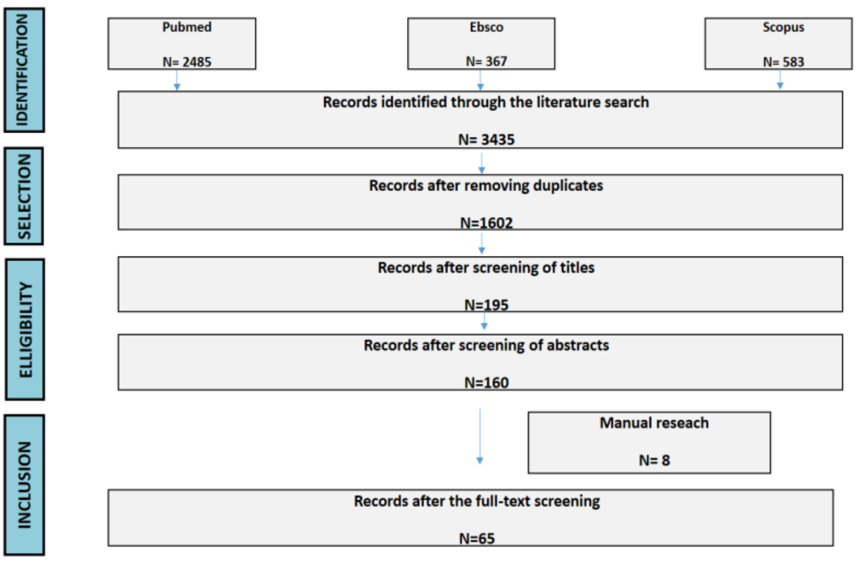

Figure 1. Literature review Flowchart

4. Discussion

4.1. Subgingival Debridement

Conventional periodontal treatment, involving mechanical scaling and root planing, was initially considered the primary treatment in the early 1970s [8]. Its primary goal is to detoxify roots, decontaminate periodontal pockets, eliminate endotoxins, and expose the collagen matrix to promote new attachment by stimulating the immune response [9,10,11]. This treatment leads to significant improvements in periodontal clinical parameters, including reduced pocket depth (PD), reduced bleeding on probing (BOP), gain in clinical attachment level (CAL), as well as a decrease in pathogenic bacteria, particularly Aggregatibacter actinomycetemcomitans (Aa) and the red complex bacteria (Porphyromonas gingivalis (Pg), Treponema denticola (Td), and Tannerella forsythia (Tf)) [9,10,11,12,13].

Root planing has been justified since Aléo's work in 1974 (10, 14). However, several researchers in the 1980s questioned the clinical necessity of removing cementum and showed that it was no longer justified [9,11,14,15]. Therefore, Smart proposed a new conservative approach in 1990, called subgingival debridement, which aims to disrupt the biofilm without over-instrumentation or intentional removal of cementum and dentin [9,16].

4.2. Conventional Periodontal Therapy Devices

Conventional periodontal therapy can be performed using either manual or mechanical instruments, or a combination of both.

4.2.1. Manual Instruments

Manual instruments are classified into five types, including sickles, curettes, files, hoes, and chisels, with sickles and curettes being the most commonly used types [10,12,17,18]. Over the years, the design of manual instruments has been improved to facilitate access to hard-to-reach areas, enhance tactile sensitivity, prevent unintentional trauma to the epithelial attachment, and maintain a neutral position of the hand, wrist, and forearm while minimizing wrist flexion [19]. Regular maintenance, such as sharpening and periodic checks, is essential to ensure the instruments' effectiveness, reduce the forces used, decrease practitioner fatigue, and improve their efficiency [10,12,15,19]. While manual instrumentation has traditionally been considered the gold standard in periodontal debridement, it demands a substantial amount of time and skill [17,18,20].

4.2.2. Mechanical Instruments

Mechanized scalers differ from manual scalers because their working parts are relatively blunt. They can be categorized as either sonic or ultrasonic, depending on their vibration frequency and production mode. Sonic scalers vibrate at frequencies between 2000/6000 and 8000 Hz and produce elliptical or orbital movements depending on their tip shape and the type of scaler used [12,15,20]. Ultrasonic scalers are the most common type and are powered by generators that convert electrical energy into ultrasonic waves. These waves cause the scaler tip to vibrate either through piezoelectricity (25 kHz-50 kHz) or magnetostriction (8 kHz-45 kHz) [12,15,17,20,21]. Ultrasonic scalers perform more effectively when they have a larger amplitude of displacement. This occurs when power is increased, workload is reduced, and wide scaling inserts are utilized (28). However, it's important to note that higher power settings also generate more heat, which could potentially lead to damage to root surfaces [12,15].

4.2.3. Ultrasonic Scalers Vs Manual Instruments

4.2.3.1. Clinical Outcomes

Numerous studies and reviews have investigated the effectiveness of manual and ultrasonic instruments in non-surgical periodontal treatment. Sculean et al. [22] conducted a randomized controlled prospective clinical study involving 38 patients, showing no significant difference between the piezoelectric ultrasonic Vector (VUS) device and manual instruments (IM) in terms of improving clinical effects, except for CAL, where they noted greater improvement in the VUS-treated group for deep pockets. A literature review [20] of 14 studies assessing the efficacy of ultrasonic instruments (Vector and periosonic) compared to IM reported no significant difference in clinical outcomes between the two methods. Chapper et al. [23] also conducted a comparative clinical study on 20 patients over a 3-month period, evaluating four groups: manual instrumentation with Hirschfeld files and Gracey curettes with or without distilled water irrigation, ultrasonic instrumentation with a piezoceramic transducer, and a fourth group combining ultrasonic instrumentation followed by manual instrumentation. They concluded that all four methods were equally effective in improving clinical parameters. A systematic review by Tunkel et al. [24] found no statistically significant difference between manual and ultrasonic instrumentation in terms of clinical outcomes. In 2004, Khosravi et al. [25] conducted an in vitro randomized clinical study comparing the efficacy of manual and ultrasonic instrumentation on the growth and attachment of gingival fibroblasts to root surfaces. The results showed a significant decrease in attachment and growth of cells on non-instrumented roots compared to healthy teeth. However, there was no significant difference in the number of attached cells or their morphology between surfaces treated with manual curettes and those treated with ultrasonic scalers. In summary, there appears to be no significant difference in clinical efficacy between manual and ultrasonic instruments in non-surgical periodontal treatment.

4.2.3.2. Root Surfaces Condition

4.2.3.2.1. Roughness of the Root Surfaces

Studies have shown mixed results regarding the effects of different instrumentation methods on root surface roughness. In 2008, Santos et al. [26] conducted an in vitro randomized clinical study involving 14 patients and 35 teeth, showing that curettes produced deeper scratches and notches, while magnetostrictive systems provided smoother root surfaces with small depressions, unlike piezoelectric systems. Conversely, Maritato et al. in 2018 [27] compared the use of manual instruments, two piezoelectric ultrasonic devices, or a combination of these methods for scaling root surfaces, finding that piezoelectric devices provided the most homogeneous and least rough surfaces. In contrast, Arabaci et al. [17] deduced, through a literature review in 2007, that the smoothest surfaces were obtained by manual instrumentation, and there was no significant difference in roughness values after sonic or ultrasonic instrumentation. However, controversy exists regarding the surface condition after instrumentation using piezoelectric and magnetostrictive scalers. Indeed, according to several studies, manual instrumentation allows significantly better tartar removal and smoother surfaces compared to sonic and ultrasonic instrumentation. Therefore, it is recommended to smooth the root surface after using ultrasonics as a final finishing procedure. Other studies have shown no significant difference between manual and mechanical instruments in terms of surface roughness.

In summary, based on the reviewed articles, all types of instrumentation have an impact on surface condition, resulting in varying degrees of roughness. However, most studies indicate that well-performed and controlled manual instrumentation tends to produce smoother surfaces compared to other methods. The design of the inserts does not appear to be significantly correlated with improved surface condition.

4.2.3.2.2. Tartar Removal

In 2008, Santos et al. [26] evaluated the effectiveness of manual and ultrasonic instrumentation methods for tartar removal. The results demonstrated that all techniques used, including manual instrumentation, piezoelectric, and magnetostrictive scalers, significantly reduced the amount of colored deposits on the root surface, with no significant difference among the three groups.

4.2.3.2.3. Cementum Removal

Bozbay et al. in 2018 [28] compared the effects of different instrumentation techniques on the amount of retained cement. They concluded that mechanized instruments were statistically more effective in retaining cement at the coronal level compared to manual instruments. Karacaoglu and Orhan in 2021 [29] compared two piezoelectric ultrasonic devices with manual instrumentation in terms of the degree of cement removal. They observed that manual instrumentation resulted in a significantly greater loss of substance than ultrasonic devices. A study by Abdul Hayei et al. in 2021 [30] concluded that thin scaler tips resulted in less substance loss than conventional scalers due to their dampening effect on the tooth surface. In summary, the aforementioned studies showed that manual instrumentation results in greater substance loss compared to ultrasonic instrumentation. Concerning the instruments used, slim scaler tips allow for better retention of cement during periodontal treatment.

4.2.3.3. Perception of Pain

Reducing pain perception during treatment can enhance patient compliance, ultimately improving the outcomes of periodontal treatment [22,30]. This is why some researchers have focused on assessing patients' pain perception. Data collected shows that piezoelectric scalers are better accepted and tolerated compared to magnetostrictive scalers and manual instruments. In a randomized controlled clinical trial conducted by Daly et al. in 2020 [21] involving 140 patients, the perception of pain, discomfort, noise, and vibration after using piezoelectric and magnetostrictive scalers was assessed. The findings revealed that patients statistically preferred the piezoelectric scaler for all measures, especially for pain and discomfort when used with warm water for irrigation. Through a literature review, Walmsley et al. in 2008 [20] demonstrated that patients experienced similar discomfort during periodontal treatment, regardless of the treatment method. However, they stated that the piezoelectric system was more comfortable for patients and better accepted compared to other ultrasonic instrumentations. Similarly, other studies cited by Sanz et al. [18] showed a decrease in pain and vibration sensation after scaling with a piezoelectric device compared to a traditional magnetostrictive ultrasonic device.

4.3. Full-Mouth Disinfection (FMD)

Conventional periodontal therapy is usually performed in several sessions, by quadrants or sextants, with weekly intervals based on severity [14,15]. However, the delay between sessions can lead to bacterial recolonization of the treated sites from other bacterial reservoirs such as the tongue, tonsils, cheeks, and untreated periodontal pockets, potentially leading to treatment failure [31]. This raises concerns about the effectiveness of such an approach [15].

In 1995, the Quyrinen team of the Catholic University of Louvain introduced the concept of full-mouth disinfection (FMD) with a 24-hour delay, usually in 2 sessions over two consecutive days, to prevent re-infection of the treated sites [32,33]. Unlike conventional methods, this protocol involves full-mouth scaling and root planing within 24 hours, followed by brushing the back of the tongue for one minute with 1% chlorhexidine (CHX) gel, rinsing the mouth with 0.2% CHX mouthwash for 2 minutes, subgingival irrigation with 1% CHX gel three times in 10 minutes, and prescribing 0.2% CHX mouthwash for 2 weeks [11,12,34].

Several researchers at the Louvain group modified this protocol. In 1995, Bollen extended the CHX irrigation duration from 2 weeks to 2 months to delay recolonization and added pharyngeal spraying with 0.2% CHX spray. Other clinicians have abandoned the use of CHX, leading to the development of the full-mouth debridement (FMSRP) approach [18,35,36].

4.3.1. FMD Vs Conventional Periodontal Treatment

4.3.1.1. Clinical Outcomes

In 2012, Konopka et al. [34] conducted a randomized study to compare the clinical efficacy of FMD to SRP in 42 patients. They found no significant difference between the two treatments, but noted that SRP resulted in better oral hygiene due to the increased number of treatment visits. However, FMD was associated with a significant reduction in volatile sulfur compounds (VSC) in exhaled air, attributed to the use of antiseptics and mechanical tongue cleaning. Sagar's literature review in 2014 [31] suggested that FMD, SRP, and FMSRP all led to good clinical results. Still, FMD may offer some advantages in terms of time. Others studies also showed a statistically significant improvement in all clinical variables (PPD, BOP, CAL) for all group, with no significant differences between them [35,36].

However, Aimetti et al. [32] conducted a randomized prospective study in 2011 on 29 patients and found that when combined with strict plaque control, FMD resulted in significant improvement in clinical parameters and reduction in bleeding on probing (BOP) and plaque index (PI). These findings were in accordance with the results of a systematic review [33] including 13 articles to compare the efficacy of FMD, FMSRP, and SRP. The results revealed a significant difference in pocket depth reduction and clinical attachment gain in favor of FMD compared to SRP, while for BOP, there was no significant difference for all three modalities.

In summary, FMD does not seem to consistently provide better clinical outcomes compared to SRP. However, it has been shown to be effective for patients suffering from halitosis.

4.3.1.2. Microbiological Outcomes

Various studies have examined the microbiological effects of Full-Mouth Disinfection (FMD), Full-Mouth Scaling and Root Planing (FMSRP), and Scaling and Root Planing (SRP).

In the randomized clinical trial conducted by Konopka et al. [34], the microbiological effect of FMD was compared to SRP. They assessed nine classic periodontopathogenic bacterial species, including Aggregatibacter actinomycetemcomitans (Aa), Porphyromonas gingivalis (Pg), Tannerella forsythia (Tf), Treponema denticola (Td), Prevotella intermedia (Pi), Eikenella corrodens (Ec), Campylobacter rectus (Cr), Fusobacterium nucleatum (Fn), and Peptostreptococcus micros (Pm). The results showed no significant reduction in bacterial species for both groups, except for a significant difference in the number of Td bacteria observed in the FMD group one month after treatment.

Similarly, other studies [31,35,37] have shown that FMD, SRP, and FMSRP resulted in a reduction in periodontopathogenic bacteria, with no significant difference between them. However, Aimetti et al. [32] found that FMD led to a significant reduction in the detection frequencies of five periodontopathogenic bacteria studied (Aa, Tf, Pi, Td, and Pg) in moderate and deep periodontal sites immediately after treatment.

In summary, data from these studies indicate that all three therapeutic approaches lead to a significant improvement in the subgingival microbiota and can be recommended for periodontal treatment.

4.4. Laser Therapy

Periodontal treatment presents challenges due to anatomical variations and the presence of a smear layer [13,38,39]. Consequently, laser therapy has emerged as a potential complementary or alternative approach [13,18,36,39].

The term "LASER" stands for Light Amplification by Stimulated Emission of Radiation, introduced in dentistry during the 1980s [12,40]. It operates within wavelengths ranging from 500 nm to 10,000 nm [40]. Laser devices emit highly coherent, monochromatic, unidirectional, and collimated light beams with low divergence [38,41]. Depending on the wavelength, four types of interactions may occur: reflection, scattering, absorption, and transmission [41,42]. In periodontology, four primary types of lasers are commonly utilized (Table 1).

Table 1. The main types of lasers used in periodontology [43,44]

Laser's type		Wavelengh
Excimer laser	Argon Fluoride (ArF),	193 – 350 nm
	Xenon Chloride (XeCl)	
Gas Lasers	Argon (Ar)	488 – 514 nm
	Helium Neon (He Ne)	632.8 nm
Solid-State Lasers	Alexandrite	337 nm
	Neodymium-Doped Yttrium Aluminium Garnet (Nd : YAG)	1064 nm
	Erbium-Doped Yttrium Aluminium Garnet (Er:YAG) Erbium, Chrome : Yttrium Scandium Gallium Garnet (Er,Cr:YSGG)	2780 – 2940 nm
Semi-conductor Lasers (Laser Diodes)	Indium Gallium Arsenide (InGaAs)	635 – 980 nm
	Gallium Aluminium Arsenide (GaAlAs)	
	Gallium Arsenide (GaAs)	

4.4.1. Benefits of Laser in Non-Surgical Periodontal Therapy

4.4.1.1. Tartar Removal

Erbium lasers (Er:YAG and Er,Cr:YSGG) have demonstrated efficacy in tartar removal and reduction of endotoxins without altering root surfaces (22). The Er:YAG laser is particularly favored for subgingival debridement [18,36,41]. Nd:YAG lasers can also remove tartar without creating a smear layer, exposing collagen fibers without widening dentinal tubule openings and enhancing root surface histocompatibility [39]. However, they may cause thermal damage and carbonization, necessitating the use of black ink as an absorber to prevent deep penetration into dental tissues [12,39], can detect deep-seated tartar[12,38,42]. Additionally, Alexandrite, ArF, and Xecl excimer lasers have shown effectiveness in tartar removal with minimal or no dental surface alterations, albeit with limited clinical application due to their high cost, large size, and ultraviolet spectrum [38].

4.4.1.2. Periodontal Pocket Decontamination

Laser therapy typically exhibits a photothermal effect, effectively eliminating most periodontal pathogens at temperatures exceeding 50 degrees Celsius [40,45]. Nd:YAG lasers demonstrate bactericidal effects against gram-negative anaerobes, including black-pigmented Bacteroides (48). Diode and Argon lasers also possess the ability to eradicate pigmented bacteria when applied in the sulcus due to their affinity for black pigments [38,40].

4.4.1.3. Healing and Regeneration of Periodontal Tissues

Low-level laser therapy (LLLT) employs photobiostimulation or photobiomodulation, directly impacting the pigments of the respiratory chain in the mitochondrial membrane. This process induces intracellular metabolic changes, leading to reduced inflammation and improved healing processes [18,38,40,42,46]. LLLT devices include GaAs, GaAlAs, infrared semiconductor, and He Ne lasers, with output powers ranging from 50 to 500 mW and wavelengths in the red or infrared spectrum [46].

4.4.2. Laser Therapy vs. Conventional Periodontal Treatment

4.4.2.1. Clinical and Inflammatory Outcomes

Studies evaluating the efficacy of laser treatment as an adjunct to Scaling and Root Planing (SRP) in periodontal therapy present mixed findings.

Gomez et al. [47] reported no significant difference between laser adjunctive therapy and SRP alone in terms of clinical outcomes but observed a reduction in interleukin-1beta (IL-1β) and tumor necrosis factor-alpha (TNF-α) levels and an increase in total antioxidant status with laser therapy. Roncati et al. [45] noted a slight reduction in pocket depth and bleeding on probing with SRP plus laser therapy (Nd:YAG or diode laser) but no significant difference in clinical attachment level. Dilsiz and Sevinc [13] found a greater loss of attachment in the control group compared to the test group, with other clinical parameters showing no significant difference between the two groups. Badran et al. [48] observed no significant differences in clinical parameters but noted a reduction in clinical attachment level with Erbium laser therapy.

Sağlam et al. [49] reported reduced pocket depth and clinical attachment level in deep pockets with Er:YAG and Nd:YAG combination therapy compared to SRP alone. De Micheli et al. [50] found improved pocket depth and clinical attachment level in the control group compared to the test group with high-intensity diode laser adjunct therapy. Similarly, Euzebio Alves et al. [51] found no significant differences in clinical parameters with high-intensity diode laser adjunct therapy to SRP. Dukić et al. [52] reported reduced pocket depth in moderately deep pockets with high-intensity diode laser adjunct therapy to SRP, with no significant differences in other clinical parameters. Matarese et al. [53] observed significant improvements in clinical parameters with diode laser adjunct therapy to SRP, particularly in pocket depth and clinical attachment level, over a one-year period.

In summary, the efficacy of laser treatment as an adjunct to SRP varies across studies, with inconsistent clinical support for its use in periodontal therapy.

4.4.2.2. Microbiological Outcomes

Studies investigating the microbiological effects of laser therapy as an adjunct to Scaling and Root Planing (SRP) versus SRP alone have provided consistent findings.

Sağlam et al. [49] in 2017 found no statistically significant difference in microbiological outcomes between Er:YAG and Nd:YAG laser therapy combined with SRP and SRP alone. Similarly, Gómez et al. [47] in 2011 demonstrated a reduction in microbial flora and bacterial species with Nd:YAG laser therapy combined with SRP, with no significant difference compared to SRP alone. De Micheli et al. [50] in 2011 reported no significant difference in the reduction of total colony-forming units (CFU) and Aggregatibacter actinomycetemcomitans (Aa) between SRP plus diode laser therapy and SRP alone. Furthermore, Euzebio Alves et al. [51] in 2013 found no significant difference in total pigment bacteria CFU reduction between high-intensity diode laser therapy and SRP alone.

However, in a controlled and randomized clinical trial, Matarese et al. [53] in 2017 evaluated the effectiveness of diode laser therapy combined with SRP on a microbiological level. They reported a significant reduction in four species of the red complex bacteria in the test group compared to the control group. Despite this, there was no significant difference in the reduction of the number of red complex species between the two groups.

In summary, regardless of the type of laser therapy used, its adjunctive application to SRP does not seem to provide additional microbiological benefits compared to SRP alone.

4.4.2.3. Root Surfaces Condition

Several studies have evaluated the impact of laser therapy, specifically Er:YAG and Er,Cr:YSGG lasers, on root surfaces during periodontal treatment. Here are the key findings from the studies reviewed:

- In an in vitro study involving 75 teeth, Mishra and Prakash [54] found that Er:YAG laser treatment, either alone or in combination with manual and ultrasonic instrumentation, effectively removed tartar deposits. However, teeth treated with the laser showed more surface loss, roughness, and minor thermal damage compared to other treatment modalities.
- Arora et al. [55], In an in vitro randomized clinical trial, reported that the Er,Cr:YSGG laser group exhibited more surface roughness, crater formation, and dentin melting compared to teeth treated with SRP alone.
- In a review of 47 articles, Agoob Alfergany et al. [56] concluded that Er:YAG laser had a comparable ability to remove tartar as SRP but was significantly better than Er,Cr:YSGG laser. However, teeth treated with Erbium lasers showed more surface roughness and removed more cementum than SRP. They suggested that precise parameter settings and feedback control are crucial for selective tartar removal without altering the root surface.

In summary, the studies reviewed suggest that Er:YAG laser can effectively remove tartar deposits during subgingival debridement. However, its use may lead to significant surface loss, roughness, and thermal damage, potentially altering the root surface. Careful consideration of laser parameters and techniques is necessary to minimize these adverse effects while maximizing its benefits in periodontal therapy.

4.5. Photodynamic Therapy (PDT)

Photodynamic therapy (PDT) has emerged as an adjunctive therapy to conventional periodontal treatment to overcome limitations associated with antibiotics, such as side effects and bacterial resistance. PDT involves activating a photosensitizer with low-power lasers or electroluminescent devices at specific wavelengths, which interacts with biomolecules to produce toxic products, causing cell death.

4.5.1. PDT vs. Conventional Periodontal Treatment

4.5.1.1. Clinical and Inflammatory Outcomes

- Moreira et al. [57] conducted a 3-month randomized controlled clinical study, showing that PDT + SRP led to a significant reduction in pocket depth (PD) and greater clinical attachment gain in deep periodontal pockets compared to SRP alone. However, inflammation markers IL-1β, IL-10, and TNF-α showed mixed results across studies.

- Betsy et al. [58] observed significant reductions in gingival index (GI), bleeding on probing (BOP), and improvements in PD and clinical attachment level (CAL) after PDT + SRP treatment.

- Azarpazhouh et al. [59] conducted a meta-analysis and found no additional clinical benefit of PDT compared to SRP alone.

- Pulikkotil et al. [60] reported a significant reduction in BOP with PDT + SRP at 3 months compared to SRP alone, while other clinical parameters showed improvement without significant differences between the two groups.

- Borekci et al. [61] found improvements in clinical parameters with both SRP with and without PDT, with a significantly greater reduction in BOP in the PDT group.

- Segarra-Vidal et al. [62] reported non-significant improvements in clinical and immunological parameters for both treatment modalities (SRP + PDT and SRP alone).

In summary, there is controversy regarding the additional clinical effects of PDT as an adjunct to SRP. While some studies show significant improvements in clinical parameters, others report mixed or non-significant results.

4.5.1.2. Microbiological Outcomes

- Moreira et al. [57] demonstrated a significant reduction in Aggregatibacter actinomycetemcomitans (Aa) and certain species of the red and orange complexes in the PDT + SRP group compared to SRP alone. Additionally, there was a significant increase in the levels of probiotic species in the PDT + SRP group.

- Segarra-Vidal et al. [62] showed a significant decrease in the bacterial load of Aa in the PDT + SRP group compared to SRP alone, with no significant difference in the reduction of Porphyromonas gingivalis (Pg) and Tannerella forsythia (Tf) between the two groups.

- Pulikkotil et al. [60] and Borekci et al. [61] reported no significant differences in the reduction of periodontopathogens between SRP with or without PDT.

In summary, both SRP with and without PDT lead to significant reductions in periodontal pathogens. However, PDT may result in a greater reduction in Aa levels, although results vary across studies.

Overall, while PDT shows promise as an adjunctive therapy, further research is needed to clarify its clinical effectiveness and optimal application in periodontal treatment.

4.6. Air Polishing (AP)

Air polishing (AP) was proposed in 1980 as a method to facilitate conventional periodontal debridement, offering an alternative or complementary approach to traditional methods. Unlike conventional polishing techniques using a cup, AP is specifically designed to remove subgingival biofilm.

AP devices operate by generating compressed air under pressure, which carries abrasive particles mixed with water. This mixture is directed onto the tooth surface to remove biofilm and stains effectively.

Various abrasive powders are utilized in AP procedures, including:

- Sodium bicarbonate ($NaHCO_3$)
- Glycine
- Calcium and sodium phosphosilicate (CaNaO6P Si)
- Calcium carbonate ($CaCO_3$)
- Aluminum trihydroxide ($Al(OH)_3$)
- Erythritol

Each powder may have specific properties and applications, and the choice of abrasive can impact the effectiveness and safety of the procedure.

Overall, AP offers a versatile approach to periodontal debridement, providing efficient removal of subgingival biofilm while minimizing damage to tooth surfaces. The selection of abrasive powder should be tailored to individual patient needs and treatment goals.

4.6.2. Air-Polishing VS Conventional Periodontal Treatment

4.6.2.1. Clinical Outcomes

Studies have evaluated the clinical outcomes of Air Polishing (AP) as an adjunct to SRP. Tsang et al. [63] conducted a six-month randomized clinical trial using glycine powder AP (GPAP) alongside SRP and observed improvements in clinical parameters for both test and control groups. Additionally, Caygur et al. [64] found no significant difference in clinical parameter improvement between GPAP as an adjunct to SRP and SRP alone.

In 2018, Park et al. [65] conducted a three-month trial using erythritol powder air polishing (EPAP) alongside SRP and observed significant improvements in clinical parameters for both treatment protocols. However, a consensus conference at EuroPerio 7 in 2012 found no significant differences in clinical outcomes between subgingival air polishing, ultrasonic debridement, and manual instruments over two months.

In summary, AP as an adjunct to SRP does not appear to provide additional clinical advantages compared to SRP alone.

4.6.2.2. Microbiological Outcomes

In 2018, Park et al. [65] compared the microbiological effects of SRP + EPAP to SRP alone and found both treatment modalities significantly decreased bacterial count. Additionally, there was a significant reduction in Pg levels in the test group compared to the control group after one month of treatment. A consensus conference at EuroPerio 7 noted that the microbiological effects of subgingival AP are comparable to those of SRP. However, GPAP led to a significant reduction in Pg load in the oral cavity.

In summary, AP as an adjunct to SRP produces similar results to SRP alone on a microbiological level. However, it appears to have an additional effect on Pg reduction.

4.6.2.3. Root Surfaces Condition in Air Polishing

Several studies have investigated the impact of air polishing (AP) on root surfaces and surrounding tissues. Here's a summary of key findings from these studies:

- Cementum Loss: Bozbay et al.[28] found that AP resulted in significantly less cementum loss compared to other treatments. Manual instrumentation followed by AP resulted in smoother surfaces, while other treatments led to surfaces with grooves and scratches.
- Gingival Trauma: Bühler et al. [66]conducted a systematic review and found that glycine powder air polishing (GPAP) resulted in less gingival trauma compared to sodium bicarbonate (NaHCO3) and manual instrumentation. NaHCO3 AP was associated with significant gingival erosion, especially in inflamed tissues.
- Hard Tissue Changes: NaHCO3 powder produced larger craters compared to other powders. Surface roughness showed no significant difference between ultrasonic instrumentation and NaHCO3 AP.
- Defect Depth: Studies by Petersilka et al. [67,68] revealed that reducing working distances and increasing powder settings led to significant defect depth, primarily influenced by instrumentation time and powder setting. Graumann et al. recommended limiting AP application to 5 seconds per dental surface with overlapping movements to minimize tissue damage.

The studies suggest that NaHCO3 AP may pose risks to dental surfaces and gingival tissues, particularly in inflamed conditions. However, GPAP at appropriate settings could be safely used in periodontal treatment without significant tissue alteration.

In summary, the choice of abrasive powder and proper application settings play crucial roles in minimizing tissue damage during AP procedures. Glycine powder appears to offer advantages over sodium bicarbonate, particularly in terms of reducing gingival trauma and cementum loss.

4.7. General Summary

The articles reviewed present a diverse range of findings regarding various non-surgical periodontal therapy modalities. Despite the heterogeneity in study types, protocols, and outcome measures, some conclusions can be drawn:

The statement suggests that while both manual and ultrasonic instrumentation methods are similarly effective in periodontal treatment, piezoelectric scalers are better tolerated by patients compared to magnetostrictive scalers and manual instruments. Overall, the preference for piezoelectric scalers due to better patient tolerance highlights the importance of considering patient comfort and experience in periodontal therapy.

The evidence suggests that FMD does not offer any additional advantages over conventional periodontal treatment methods. This implies that the use of FMD alongside standard treatment protocols does not result in superior clinical outcomes or improvements in periodontal health compared to traditional approaches.

While laser therapy, particularly using the Er:YAG laser, can be effective for subgingival debridement, it does not generally lead to better results compared to scaling and root planing (SRP), which is considered the gold standard in non-surgical periodontal therapy. Additionally, the use of lasers, including the Er:YAG laser, may carry the risk of causing thermal damage to tissues, highlighting a potential drawback of this treatment modality.

The introduction of PDT as an adjunctive therapy to SRP does not seem to provide complementary effects or additional benefits in improving periodontal treatment outcomes. Therefore, based on available evidence, PDT is not recommended as a routine adjunct to SRP in periodontal therapy protocols.

Glycine powder air polishing (GPAP) is recognized as the preferred abrasive powder for air polishing procedures. However, despite its efficacy in biofilm removal, air polishing does not offer any additional advantages over scaling and root planing (SRP) in terms of treatment outcomes. Therefore, while GPAP may be effective for biofilm removal, its use as an adjunct to SRP is not warranted based on current evidence.

Laser therapy, photodynamic therapy (PDT), and air polishing are not recommended as adjunctive therapies to SRP in periodontal treatment protocols. The additional cost associated with these modalities is not justified by their limited efficacy in improving treatment outcomes compared to SRP alone.

The choice between traditional periodontal treatment methods and full-mouth disinfection (FMD) can vary based on factors such as time constraints, practitioner experience and fatigue, and patient preference. Both manual and ultrasonic instrumentation, either alone or in combination, can be used effectively in initial periodontal therapy based on individual clinical considerations.

These statements highlight the importance of evidence-based decision-making in selecting appropriate adjunctive therapies for periodontal treatment. While certain modalities may offer advantages in specific contexts, their routine use alongside SRP may not necessarily lead to improved treatment outcomes.

5. Conclusion

This conclusion succinctly summarizes the current status of non-surgical periodontal therapy:

Currently, conventional subgingival debridement (SRP) remains the gold standard in non-surgical periodontal therapy. It serves as the benchmark against which new approaches are evaluated.

While new therapeutic approaches have shown promise in improving the outcomes of SRP, none have demonstrated significantly superior efficacy compared to SRP alone. This underscores the importance of further research to establish their clinical relevance.

To better understand the efficacy and clinical relevance of these new approaches, there is a need for high-quality, long-term studies with larger sample sizes and more standardized clinical protocols. Such studies would provide more robust evidence to guide clinical practice.

It would also be valuable to assess the efficacy of these therapeutic approaches not only as adjuncts to SRP but also as monotherapy and as alternatives to SRP during reevaluation and maintenance phases of periodontal treatment.

In conclusion, while there is potential for new approaches to enhance the outcomes of non-surgical periodontal therapy, further research is needed to establish their efficacy, clinical relevance, and suitability for different phases of treatment.

References

[1] M. Sanz *et al.*, 'Treatment of stage I-III periodontitis-The EFP S3 level clinical practice guideline', *J. Clin. Periodontol.*, vol. 47 Suppl 22, pp. 4–60, Jul. 2020.

[2] OMS, 'Santé bucco-dentaire'. Accessed: Dec. 02, 2022. [Online]. Available: https:// www.who.int/ fr/ news-room/fact-sheets/ detail/oral-health.

[3] J. Kissa *et al.*, 'National survey of periodontal diseases in adolescents and young adults in Morocco', *J. Clin. Periodontol.*, vol. 49, no. 5, pp. 439–447, May 2022.

[4] J. Kissa *et al.*, 'Prevalence of periodontal disease in young Moroccans: A national survey', *J. Periodontol.*, Jun. 2022.

[5] D. F. Kinane, P. G. Stathopoulou, and P. N. Papapanou, 'Periodontal diseases', *Nat. Rev. Dis. Primer*, vol. 3, p. 17038, Jun. 2017.

[6] R. G. Caffesse and J. J. Echeverría, 'Treatment trends in periodontics', *Periodontol. 2000*, vol. 79, no. 1, pp. 7–14, 2019.

[7] M. Nazir, A. Al-Ansari, K. Al-Khalifa, M. Alhareky, B. Gaffar, and K. Almas, 'Global Prevalence of Periodontal Disease and Lack of Its Surveillance', *Sci. World J.*, vol. 2020, p. 2146160, May 2020.

[8] L. Abdellaoui, 'Evolution of concepts in periodontology. Part 2 : Evolution of diagnosis and treatment strategies for periodontal diseases. - ROS - 2007 - Tome 36 - N°3 - Revue Odonto Stomatologique - SOP'. Accessed: May 26, 2021. [Online]. Available: https:// www.sop.asso.fr/ revue-odonto-stomatologique/ 207-evolution-des-concepts-en-parodontologie-2eme-partie-evolution-des-strategies-de-diagnostic-et-de-traitement-des-maladies-parodontales/en.

[9] M. Ciantar, 'Time to shift: from scaling and root planing to root surface debridement', *Prim. Dent. J.*, vol. 3, no. 3, pp. 38–42, Aug. 2014.

[10] B. Mullally, C. Irwin, H. Ziada, E. Allen, and P. J. Byrne, 'Periodontics: 3. Non-surgical periodontal therapy in general dental practice', *Dent. Update*, vol. 34, no. 6, pp. 326–328, 330–332, 335–336, Aug. 2007.

[11] A. Popelut, S. Mouraret, B. Halabi, and H. Rangé, 'Résultats des thérapeutiques parodontales actuelles', *Réal. Clin.*, vol. 23, p. 8.

[12] I. Darby, 'Non-surgical management of periodontal disease', *Aust. Dent. J.*, vol. 54 Suppl 1, pp. S86-95, Sep. 2009.

[13] A. Dilsiz and S. Sevinc, 'Trauma from instrumentation after non-surgical periodontal treatment with ultrasonic scalers and Nd:YAG laser', *Acta Odontol. Scand.*, vol. 73, no. 2, pp. 144–149, Feb. 2015.

[14] D. A. Apatzidou, 'Modern approaches to non-surgical biofilm management', *Front. Oral Biol.*, vol. 15, pp. 99–116, 2012.

[15] R. Krishna and J. A. De Stefano, 'Ultrasonic vs. hand instrumentation in periodontal therapy: clinical outcomes', *Periodontol. 2000*, vol. 71, no. 1, pp. 113–127, Jun. 2016.

[16] C. H. Drisko, 'Nonsurgical periodontal therapy', *Periodontol. 2000*, vol. 25, pp. 77–88, 2001.

[17] T. Arabaci, Y. Ciçek, and C. F. Canakçi, 'Sonic and ultrasonic scalers in periodontal treatment: a review', *Int. J. Dent. Hyg.*, vol. 5, no. 1, pp. 2–12, Feb. 2007.

[18] I. Sanz, B. Alonso, M. Carasol, D. Herrera, and M. Sanz, 'Nonsurgical treatment of periodontitis', *J. Evid.-Based Dent. Pract.*, vol. 12, no. 3 Suppl, pp. 76–86, Sep. 2012.

[19] Nancy K. Mann, 'The Blended Approach to Instrumentation', Dimensions of Dental Hygiene. Accessed: Nov. 07, 2021. [Online]. Available: https:// dimensionsofdentalhygiene.com/ article/the-blended-approach-to-instrumentation/.

[20] A. D. Walmsley, S. C. Lea, G. Landini, and A. J. Moses, 'Advances in power driven pocket/root instrumentation', *J. Clin. Periodontol.*, vol. 35, no. 8 Suppl, pp. 22–28, Sep. 2008.

[21] S. Daly, R. G. Newcombe, N. C. A. Claydon, J. Seong, M. Davies, and N. X. West, 'A randomised controlled trial to determine patient experience of a magnetostrictive stack scaler as compared to a piezoelectric scaler, in supportive periodontal therapy', *J. Dent.*, vol. 93, p. 103279, Feb. 2020.

[22] A. Sculean *et al.*, 'Non-surgical periodontal treatment with a new ultrasonic device (Vector-ultrasonic system) or hand instruments', *J. Clin. Periodontol.*, vol. 31, no. 6, pp. 428–433, Jun. 2004.

[23] A. Chapper, V. V. Catão, and R. V. Oppermann, 'Hand and ultrasonic instrumentation in the treatment of chronic periodontitis after supragingival plaque control', *Braz. Oral Res.*, vol. 19, no. 1, pp. 41–46, Mar. 2005.

[24] J. Tunkel, A. Heinecke, and T. F. Flemmig, 'A systematic review of efficacy of machine-driven and manual subgingival debridement in the treatment of chronic periodontitis', *J. Clin. Periodontol.*, vol. 29 Suppl 3, pp. 72–81; discussion 90-91, 2002.

[25] M. Khosravi, Z. S. Bahrami, M. S. J. Atabaki, M. A. Shokrgozar, and F. Shokri, 'Comparative effectiveness of hand and ultrasonic instrumentations in root surface planing in vitro', *J. Clin. Periodontol.*, vol. 31, no. 3, pp. 160–165, Mar. 2004.

[26] F. A. Santos, M. T. Pochapski, P. C. Leal, P. P. Gimenes-Sakima, and E. Marcantonio, 'Comparative study on the effect of ultrasonic instruments on the root surface in vivo', *Clin. Oral Investig.*, vol. 12, no. 2, pp. 143–150, Jun. 2008.

[27] M. Maritato *et al.*, 'Root surface alterations following manual and mechanical scaling: A comparative study', *Int. J. Dent. Hyg.*, vol. 16, no. 4, pp. 553–558, Nov. 2018.

[28] E. Bozbay *et al.*, 'Preservation of root cementum: a comparative evaluation of power-driven versus hand instruments', *Int. J. Dent. Hyg.*, vol. 16, no. 2, pp. 202–209, May 2018.

[29] F. Karacaoglu and K. Orhan, 'Comparison of the effects of different instrumentation techniques on root surface roughness and cement loss using micro-computerized tomography: An in-vitro study', *Int. J. Dent. Hyg.*, Aug. 2021.

[30] N. A. Abdul Hayei, N. A. Yahya, S. H. Safii, R. Saub, R. D. Vaithilingam, and N. A. Baharuddin, 'Influence of scaler tip design on root surface roughness, tooth substance loss and patients' pain perception: an in vitro and a randomised clinical trial', *BMC Oral Health*, vol. 21, no. 1, p. 169, Mar. 2021.

[31] A. Sagar, 'Full mouth versus quadrant treatment in chronic periodontitis', *Prim. Dent. J.*, vol. 3, no. 3, pp. 66–69, Aug. 2014.

[32] M. Aimetti, F. Romano, N. Guzzi, and G. Carnevale, 'One-stage full-mouth disinfection as a therapeutic approach for generalized aggressive periodontitis', *J. Periodontol.*, vol. 82, no. 6, pp. 845–853, Jun. 2011.

[33] H. Fang, M. Han, Q.-L. Li, C. Y. Cao, R. Xia, and Z.-H. Zhang, 'Comparison of full-mouth disinfection and quadrant-wise scaling in the treatment of adult chronic periodontitis: a systematic review and meta-analysis', *J. Periodontal Res.*, vol. 51, no. 4, pp. 417–430, Aug. 2016.

[34] T. Konopka, E. Karolewska, and A. Rzeszut, 'Clinical and microbiological effects of full-mouth disinfection versus conventional treatment of chronic periodontitis', *J. Stomatol.*, vol. 65, pp. 6–23, Jan. 2012.

[35] N. P. Lang, W. C. Tan, M. A. Krähenmann, and M. Zwahlen, 'A systematic review of the effects of full-mouth debridement with and without antiseptics in patients with chronic periodontitis', *J. Clin. Periodontol.*, vol. 35, no. 8 Suppl, pp. 8–21, Sep. 2008.

[36] A. Plessas, 'Nonsurgical periodontal treatment: review of the evidence', *Oral Health Dent. Manag.*, vol. 13, no. 1, pp. 71–80, Mar. 2014.

[37] G. U. Knöfler, R. E. Purschwitz, and H. F. R. Jentsch, 'Clinical evaluation of partial- and full-mouth scaling in the treatment of chronic periodontitis', *J. Periodontol.*, vol. 78, no. 11, pp. 2135–2142, Nov. 2007.

[38] A. Aoki, K. M. Sasaki, H. Watanabe, and I. Ishikawa, 'Lasers in nonsurgical periodontal therapy', *Periodontol. 2000*, vol. 36, pp. 59–97, 2004.

[39] M. Mavrogiannis, J. M. Thomason, and R. A. Seymour, 'Lasers in periodontology', *Dent. Update*, vol. 31, no. 9, pp. 535–538, 541–542, 545–547, Nov. 2004.

[40] S. B. Low and A. Mott, 'Laser Technology to Manage Periodontal Disease: A Valid Concept?', *J. Evid. Based Dent. Pract.*, vol. 14, pp. 154–159, Jun. 2014.

[41] C. M. Cobb, 'Lasers in periodontics: a review of the literature', *J. Periodontol.*, vol. 77, no. 4, pp. 545–564, Apr. 2006.

[42] I. Ishikawa, A. Aoki, A. A. Takasaki, K. Mizutani, K. M. Sasaki, and Y. Izumi, 'Application of lasers in periodontics: true innovation or myth?', *Periodontol. 2000*, vol. 50, pp. 90–126, 2009.

[43] C. M. Cobb, 'Lasers in periodontics: a review of the literature', *J. Periodontol.*, vol. 77, no. 4, pp. 545–564, Apr. 2006.

[44] M. Mavrogiannis, J. M. Thomason, and R. A. Seymour, 'Lasers in periodontology', *Dent. Update*, vol. 31, no. 9, pp. 535–538, 541–542, 545–547, Nov. 2004.

[45] M. Roncati and A. Gariffo, 'Systematic review of the adjunctive use of diode and Nd:YAG lasers for nonsurgical periodontal instrumentation', *Photomed. Laser Surg.*, vol. 32, no. 4, pp. 186–197, Apr. 2014.

[46] Brindha and R. Devi, 'Low-Level Laser Therapy in Periodontics:A Review Article', *J. Acad. Dent. Educ.*, vol. 4, no. 2, pp. 12–16, Dec. 2018.

[47] C. Gómez, A. Domínguez, A. I. García-Kass, and J. A. García-Nuñez, 'Adjunctive Nd:YAG laser application in chronic periodontitis: clinical, immunological, and microbiological aspects', *Lasers Med. Sci.*, vol. 26, no. 4, pp. 453–463, Jul. 2011.

[48] Z. Badran, H. Boutigny, X. Struillou, P. Weiss, O. Laboux, and A. Soueidan, 'Clinical outcomes after nonsurgical periodontal therapy with an Er:YAG laser device: a randomized controlled pilot study', *Photomed. Laser Surg.*, vol. 30, no. 7, pp. 347–353, Jul. 2012.

[49] M. Sağlam, S. Köseoğlu, I. Taşdemir, H. Erbak Yılmaz, L. Savran, and R. Sütçü, 'Combined application of Er:YAG and Nd:YAG lasers in treatment of chronic periodontitis. A split-mouth, single-blind, randomized controlled trial', *J. Periodontal Res.*, vol. 52, no. 5, pp. 853–862, Oct. 2017.

[50] G. De Micheli, A. K. P. de Andrade, V. T. E. Alves, M. Seto, C. M. Pannuti, and S. Cai, 'Efficacy of high intensity diode laser as an adjunct to non-surgical periodontal treatment: a randomized controlled trial', *Lasers Med. Sci.*, vol. 26, no. 1, pp. 43–48, Jan. 2011.

[51] V. T. Euzebio Alves *et al.*, 'Clinical and microbiological evaluation of high intensity diode laser adjutant to non-surgical periodontal treatment: a 6-month clinical trial', *Clin. Oral Investig.*, vol. 17, no. 1, pp. 87–95, Jan. 2013.

[52] W. Dukić, I. Bago, A. Aurer, and M. Roguljić, 'Clinical effectiveness of diode laser therapy as an adjunct to non-surgical periodontal treatment: a randomized clinical study', *J. Periodontol.*, vol. 84, no. 8, pp. 1111–1117, Aug. 2013.

[53] G. Matarese, L. Ramaglia, M. Cicciù, G. Cordasco, and G. Isola, 'The Effects of Diode Laser Therapy as an Adjunct to Scaling and Root Planing in the Treatment of Aggressive Periodontitis: A 1-Year Randomized Controlled Clinical Trial', *Photomed. Laser Surg.*, vol. 35, no. 12, pp. 702–709, Dec. 2017.

[54] M. K. Mishra and S. Prakash, 'A comparative scanning electron microscopy study between hand instrument, ultrasonic scaling and erbium doped:Yttirum aluminum garnet laser on root surface: A morphological and thermal analysis', *Contemp. Clin. Dent.*, vol. 4, no. 2, pp. 198–205, Apr. 2013.

[55] S. Arora, A. K. Lamba, F. Faraz, S. Tandon, and A. Ahad, 'Evaluation of the Effects of Er,Cr:YSGG Laser, Ultrasonic Scaler and Curette on Root Surface Profile Using Surface Analyser and Scanning Electron Microscope: An In Vitro Study', *J. Lasers Med. Sci.*, vol. 7, no. 4, pp. 243–249, 2016.

[56] M. Agoob Alfergany, R. Nasher, and N. Gutknecht, 'Calculus Removal and Root Surface Roughness When Using the Er:YAG or Er,Cr:YSGG Laser Compared with Conventional Instrumentation Method: A Literature Review', *Photobiomodulation Photomed. Laser Surg.*, vol. 37, no. 4, pp. 197–226, Apr. 2019.

[57] A. L. Moreira *et al.*, 'Antimicrobial photodynamic therapy as an adjunct to non-surgical treatment of aggressive periodontitis: a split-mouth randomized controlled trial', *J. Periodontol.*, vol. 86, no. 3, pp. 376–386, Mar. 2015.

[58] J. Betsy, C. S. Prasanth, K. V. Baiju, J. Prasanthila, and N. Subhash, 'Efficacy of antimicrobial photodynamic therapy in the management of chronic periodontitis: a randomized controlled clinical trial', *J. Clin. Periodontol.*, vol. 41, no. 6, pp. 573–581, Jun. 2014.

[59] A. Azarpazhooh, P. S. Shah, H. C. Tenenbaum, and M. B. Goldberg, 'The effect of photodynamic therapy for periodontitis: a systematic review and meta-analysis', *J. Periodontol.*, vol. 81, no. 1, pp. 4–14, Jan. 2010.

[60] S. J. Pulikkotil, C. G. Toh, K. Mohandas, and K. Leong, 'Effect of photodynamic therapy adjunct to scaling and root planing in periodontitis patients: A randomized clinical trial', *Aust. Dent. J.*, vol. 61, no. 4, pp. 440–445, Dec. 2016.

[61] T. Borekci, S. E. Meseli, U. Noyan, B. E. Kuru, and L. Kuru, 'Efficacy of adjunctive photodynamic therapy in the treatment of generalized aggressive periodontitis: A randomized controlled clinical trial', *Lasers Surg. Med.*, vol. 51, no. 2, pp. 167–175, Feb. 2019.

[62] M. Segarra-Vidal *et al.*, 'Effects of photodynamic therapy in periodontal treatment: A randomized, controlled clinical trial', *J. Clin. Periodontol.*, vol. 44, no. 9, pp. 915–925, Sep. 2017.

[63] Y. C. Tsang, E. F. Corbet, and L. J. Jin, 'Subgingival glycine powder air-polishing as an additional approach to nonsurgical periodontal therapy in subjects with untreated chronic periodontitis', *J. Periodontal Res.*, vol. 53, no. 3, pp. 440–445, Jun. 2018.

[64] A. Caygur, M. R. Albaba, A. Berberoglu, and H. G. Yilmaz, 'Efficacy of glycine powder air-polishing combined with scaling and root planing in the treatment of periodontitis and halitosis: A randomised clinical study', *J. Int. Med. Res.*, vol. 45, no. 3, pp. 1168–1174, Jun. 2017.

[65] E.-J. Park, E.-Y. Kwon, H.-J. Kim, J.-Y. Lee, J. Choi, and J.-Y. Joo, 'Clinical and microbiological effects of the supplementary use of an erythritol powder air-polishing device in non-surgical periodontal therapy: a randomized clinical trial', *J. Periodontal Implant Sci.*, vol. 48, no. 5, pp. 295–304, Oct. 2018.

[66] J. Bühler, M. Amato, R. Weiger, and C. Walter, 'A systematic review on the effects of air polishing devices on oral tissues', *Int. J. Dent. Hyg.*, vol. 14, no. 1, pp. 15–28, Feb. 2016.

[67] G. J. Petersilka, 'Subgingival air-polishing in the treatment of periodontal biofilm infections', *Periodontol. 2000*, vol. 55, no. 1, pp. 124–142, 2011.

[68] G. Petersilka, M. Bell, A. Mehl, R. Hickel, and T. Flemmig, 'Root defects following air polishing', *J. Clin. Periodontol.*, vol. 30, pp. 165–70, Mar. 2003.