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Comparative Analysis of Magnetostrictive and Piezoelectric Ultrasonic Scalers In Periodontal Therapy

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Abstract

Non-surgical periodontal therapy, particularly scaling and root planing, serves as the cornerstone of periodontal disease management. These procedures may be performed manually or using ultrasonic instruments. Among ultrasonic scalers, magnetostrictive and piezoelectric types are the most commonly used, each operating based on distinct mechanical principles and exhibiting different biological effects. The choice of scaler can influence both treatment efficacy and patient comfort. **Objective:** This review aims to compare magnetostrictive and piezoelectric ultrasonic scalers in periodontal therapy, focusing on clinical effectiveness, impact on hard and soft tissues as well as patient comfort. **Discussion :** Both types of scalers are effective at removing biofilm and calculus. Piezoelectric scalers operate with linear motion and generate less heat, while magnetostrictive scalers utilize elliptical motion. Some studies suggest that piezoelectric devices offer greater patient comfort and cause less tissue trauma, though these differences are not always statistically significant. **Conclusion:** The differing mechanisms of magnetostrictive and piezoelectric scalers offer clinicians flexible options that can be adjusted to individual patient needs. A thorough understanding of each system is essential for optimizing treatment outcomes while ensuring patient safety and comfort.

Keywords: Ultrasonic scaler; magnetostrictive; piezoelectric; root surface roughness; patient comfort

1. Introduction

Periodontal disease is a chronic inflammatory condition affecting the supporting structures of the teeth, primarily caused by the accumulation of dental plaque. This plaque hosts a complex community of microorganism, particularly anaerobic bacteria, which contribute to the onset and progression of the disease. It typically begins as gingivitis and, if left untreated, may progress to periodontitis.[1] Without proper management, the resulting inflammation can lead to attachment loss and alveolar bone resorption. Moreover, periodontitis has been linked to various systemic conditions, such as diabetes mellitus and cardiovascular disorders.[2] Early intervention, in line with the consensus outlined by the European Federation of Periodontology's S3 Clinical Practice Guideline, is crucial for stabilizing periodontal health.[3]

The initial recommended approach for managing periodontal disease is non- surgical therapy, particularly scaling and root planing (SRP). This procedure aims to remove biofilm, calculus, and endotoxins adhered to root surfaces, thereby reducing bacterial colonization and promoting the healing of the periodontal tissues. SRP has been widely validated as an effective method for controlling disease progression and is considered a fundamental component of the initial phase of periodontal therapy.[4]

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Advancements in dental technology, manual instruments have increasingly been supplemented by mechanical tools, notably ultrasonic scalers. While manual instruments such as Gracey curettes offer precise control, they may be limited in accessing deep subgingival areas and present ergonomic challenges for clinicians. These limitations have led to the broader adoption of ultrasonic devices to enhance the efficiency and effectiveness of periodontal treatment.[5,6]

The two primary types of ultrasonic scalers commonly used in clinical practice are magnetostrictive and piezoelectric. These devices differ in their source of energy and motion mechanism: magnetostrictive scalers produce elliptical motion through magnetic fields, whereas piezoelectric scalers generate linear motion via vibrations from piezoelectric crystals. These mechanical distinctions influence clinical performance, patient comfort, and tissue response during treatment.[7,8]

Both types have demonstrated comparable clinical efficacy in reducing pocket depth and improving clinical attachment levels. However, piezoelectric scalers tend to offer better heat control and operate more quietly, contributing to enhanced patient comfort. On the other hand, magnetostrictive scalers provide greater flexibility in tip selection, which can be advantageous when adapting to root morphology or complex clinical situations.[9]

1.1. Introduction

This literature review aims to compare magnetostrictive and piezoelectric ultrasonic scalers in periodontal therapy, with a focus on clinical efficacy, impact on hard and soft tissues, and patient comfort during treatment.

2. Literature Review

2.1. Scaling as a Component of Periodontal Therapy

Supportive periodontal therapy is considered the gold standard for maintaining periodontal stability, particularly in patients susceptible to periodontal disease. Scaling is a key component of this maintenance phase. Although it can be performed using manual instruments, such procedures tend to be time-consuming. Thus, ultrasonic scaling has emerged as a practical and efficient alternative in periodontal therapy.

Mechanical debridement, the removal of biofilm and calculus from periodontal tissues, forms the foundation of treatment for all inflammatory periodontal diseases. It is regarded as the gold standard for both initial non-surgical and surgical therapy.[10] Among mechanical debridement techniques, scaling is particularly effective in eliminating even mineralized deposits.[11] Scaling procedures are capable of targeting both supragingival and accessible subgingival biofilm.[12] Multiple studies have confirmed that periodontitis patients undergoing regular scaling show significant improvements in periodontal health and stabilization of disease progression.[13]

2.2. Scaler Ultrasonic

Ultrasonic scalers were first introduced in the 1950s for tooth surface cleaning and became widely available and commonly used by the 1970.[11] (Figure 1) These devices operate using sound waves that are beyond the range of human hearing due to their high frequency.[12] The two primary mechanisms underlying ultrasonic scaler function are cavitation and acoustic turbulence.[13]

The cavitation effect is produced when the high-frequency vibrations of ultrasonic waves interact with water. This interaction generates fluid motion that influences the movement of the instrument tip. As the water flows into low-pressure areas, it begins to boil and forms vapor bubbles. These bubbles then travel into high-pressure zones, where the vapor rapidly condenses back into liquid, causing the bubbles to collapse explosively. This phase transition from gas to liquid is accompanied by the breakdown and formation of ions such as H^+ and OH^- (Figure 2).[12] In addition to cavitation, acoustic turbulence and fluid flow play important roles in the mechanism of ultrasonic scalers. Acoustic turbulence refers to a unidirectional, agitating motion generated by the continuous flow of cooling liquid during instrumentation. This hydrodynamic action contributes to the disruption of subgingival biofilm and the elimination of pathogenic bacteria within periodontal pockets.[13]

Figure 1. *Scaler Ultrasonic*[13]

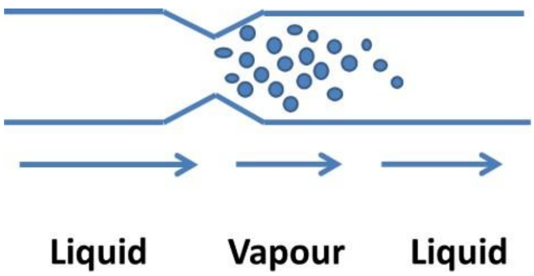

Figure 2. *Cavitation effect*[12]

2.3. Working Principles and Characteristics of Ultrasonic Scalers

Ultrasonic scalers operate by generating high-frequency vibrations that effectively break up and remove hard deposits and biofilm from tooth surfaces. These vibrations typically range from 25,000 to 50,000 cycles per second (Hz). In addition to mechanical vibrations, ultrasonic devices also produce acoustic effects such as **cavitation** and **microstreaming**, which help disrupt the integrity of subgingival biofilm.[10] The synergy between mechanical and hydrodynamic actions makes ultrasonic scalers highly effective for periodontal therapy.

2.3.1. Magnetostrictive Scalers

Magnetostrictive scalers function based on the principle of electromagnetic induction. An electromagnetic coil located within the handpiece generates a magnetic field that induces vibration in a stack of ferromagnetic metal strips. These vibrations are transmitted to the tip of the instrument, resulting in an elliptical or circular motion.[14] This movement occurs in four dimensions, allowing all surfaces of the tip to be active. However, this design also generates more heat, necessitating sufficient water flow for cooling.[15]

Magnetostrictive scalers typically operate at frequencies between 18–45 kHz, with amplitudes ranging from 13–72 µm depending on device design and power settings. A notable advantage of this system is the flexibility of the tip movement, which aids in adapting to various root anatomies. However, drawbacks include increased local heat generation and stronger vibrations, which may cause discomfort in some patients.[16]

2.3.2. Piezoelectric Scalers

Piezoelectric scalers utilize piezoelectric crystals embedded within the handpiece. When an electric current is applied, these crystals undergo rapid dimensional changes due to the piezoelectric effect, producing mechanical vibrations that are transmitted to the scaler tip. Unlike magnetostrictive systems, piezoelectric tips move in a linear pattern— typically in two dimensions, oscillating laterally—making only the lateral surfaces of the tip active.[17,18]

These devices usually operate within a frequency range of 25–50 kHz and have a smaller amplitude compared to magnetostrictive units. The precise, linear movement allows for better control and minimizes the risk of soft tissue trauma. Furthermore, the efficient energy conversion of the crystals produces less heat, requiring less water for cooling.[15]

2.3.3. Comparison of Mechanical and Clinical Characteristics

The table summarizes the key characteristics of magnetostrictive and piezoelectric ultrasonic scalers:

Table 1. Key characteristics of magnetostrictive and piezoelectric

Characteristic	Magnetostrictive	Piezoelectric
Energy Source	Electromagnetic field	Piezoelectric crystal
Tip Movement	Elliptical / sirkular	Linear (lateral back-and-forth)
Active Tip Surface	All sides	One or two sides
Operating Frequency	18-45 kHz	25-50 kHz
Heat Generation	Higher	Lower
Tissue Trauma Potential	Higher	Minimal
Patient Comfort	Variable	Generally more comfortable

The differences in working mechanisms affect not only the technical performance of the devices but also influence the biological response of periodontal tissues and the overall comfort experienced by the patient during treatment. A thorough understanding of the unique characteristics of each scaler type is essential for making appropriate clinical decisions, tailored to the patient's specific condition and therapeutic goals.\

2.4. Clinical Efficacy of Magnetostrictive and Piezoelectric Scalers in Periodontal Therapy

Clinical efficacy is a key parameter in assessing the success of non-surgical periodontal therapy, particularly scaling and root planing (SRP). This efficacy is measured by the extent to which an instrument can remove subgingival biofilm and calculus, reduce probing pocket depth (PPD), and promote clinical attachment gain. Both magnetostrictive and piezoelectric ultrasonic scalers have been shown to be effective in supporting these therapeutic goals, although they differ in their technical operation and biological effects.

2.5. Effect on Biofilm and Calculus Removal

Numerous studies have demonstrated that both types of ultrasonic scalers offer comparable capabilities in removing subgingival deposits. This finding is supported by research from Lea et al., who confirmed that both piezoelectric and magnetostrictive scalers are equally effective in reducing pathogenic microorganisms on root surfaces.[17] Similarly, Drisko highlighted that the effectiveness of biofilm and calculus removal depends more on the operator's technique and the accessibility of the periodontal area than on the type of scaler used.[19]

However, some evidence suggests a relative advantage of piezoelectric scalers, particularly in anatomically challenging areas. Their linear motion and controlled vibrational direction allow for enhanced access to narrow or curved root surfaces, thus facilitating more precise debridement procedures.[20]

2.6. Effect on Periodontal Clinical Parameters

Clinical parameter such as probing pocket depth and clinical attachment loss, several meta-analyses indicate no significant difference between magnetostrictive and piezoelectric scaler usage in short- to mid-term outcomes. A randomized controlled trial conducted by Matin et al. reported that both scaler types effectively reduced pocket depth and improved attachment levels after three months of treatment, with no statistically significant differences between them.[21]

A crossover study by Alwaeli et al. further noted that piezoelectric scalers were associated with lower patient discomfort, yet clinical results—including bleeding on probing (BOP), probing depth, and attachment loss—remained comparable after a single treatment visit.[22]

2.7. Additional Clinical Consideration

The clinical efficacy of ultrasonic scalers may also be influenced by several auxiliary factors, including the shape of the tip, the mode of operation (continuous vs. intermittent), and the cooling capacity provided by the water irrigation system integrated into the instrument. Piezoelectric scalers typically operate with quieter sound levels and smoother vibrations, which can enhance patient comfort and contribute positively to overall treatment compliance. In contrast, magnetostrictive scalers offer a wider variety of tip shapes, allowing better adaptation to the complex root surface morphology often encountered in periodontal therapy.[14]

2.8. Effects on Hard and Soft Tissues

In non-surgical periodontal therapy, it is crucial to evaluate not only the cleaning efficacy of ultrasonic scalers but also their potential effects on the integrity of both hard and soft oral tissues.

2.8.1. Effects on Hard Tissues

Root surfaces exposed due to chronic periodontal disease often exhibit demineralization or structural alterations induced by prolonged inflammation. Although ultrasonic scaling is intended to remove biofilm and calculus, it can also cause changes to root surface morphology depending on factors such as the duration of instrumentation, the amount of pressure applied, and the type of tip used.

Several studies have reported that both magnetostrictive and piezoelectric scalers can alter the root surface when applied aggressively. However, piezoelectric scalers, due to their linear motion and lower amplitude, tend to induce less dentin loss compared to magnetostrictive units, which operate with elliptical motion and higher amplitude.[17] Walmsley et al., stated the use of light pressure and an appropriately selected tip is essential to minimizing mechanical damage to the root structure.[14]

Additionally, heat generation from ultrasonic vibrations can impact the dentin and cementum, particularly if the water irrigation system fails to function optimally. Piezoelectric devices are generally associated with lower thermal output due to their superior energy efficiency, which reduces the risk of overheating and subsequent damage to hard tissues.[22]

2.8.2. Effects on Soft Tissues

Soft tissue structures, such as the gingiva and junctional epithelium, are also susceptible to trauma during ultrasonic instrumentation. Excessive mechanical force or poor control of the tip's motion can lead to secondary inflammation and delay the healing process. The linear motion of piezoelectric scalers allows for more precise control of the instrument's direction, thereby reducing the risk of soft tissue trauma.

A clinical trial conducted by Alwaeli et al. reported that patients treated with piezoelectric scalers experienced less postoperative bleeding and discomfort, suggesting a lower level of soft tissue trauma compared to magnetostrictive devices. However, this difference was not clinically significant and was found to be more closely related to operator proficiency than the type of scaler used.[16]

Beyond mechanical factors, ultrasonic vibrations may also influence biological responses in soft tissues. Preliminary evidence suggests that ultrasonic waves may modulate inflammatory mediators in periodontal tissues, though these findings remain exploratory and warrant further investigation.[14]

3. Discussion

Instrument selection plays a critical role in the success of non-surgical periodontal therapy. Both magnetostrictive and piezoelectric ultrasonic scalers have demonstrated comparable effectiveness in the removal of subgingival biofilm and calculus. Additionally, they have been shown to contribute similarly to improvements in key clinical parameters such as probing depth reduction, clinical attachment gain, and decreased bleeding on probing. Studies comparing the two technologies generally conclude that there is no statistically significant difference in clinical outcomes, particularly in short- to medium-term follow-up periods.[22]

Despite their similar clinical efficacy, magnetostrictive and piezoelectric ultrasonic scalers operate via fundamentally different mechanisms. Magnetostrictive scalers function at frequencies ranging from 18 kHz to 45 kHz and utilize a metal rod at the tip of the handpiece, which vibrates in an elliptical motion.[23] In contrast, piezoelectric scalers operate at slightly higher frequencies, typically between 25 kHz and 50 kHz. They transmit electrical energy through a handpiece to a crystal element, resulting in a linear vibration pattern at the tip.[24] (Figure 3).

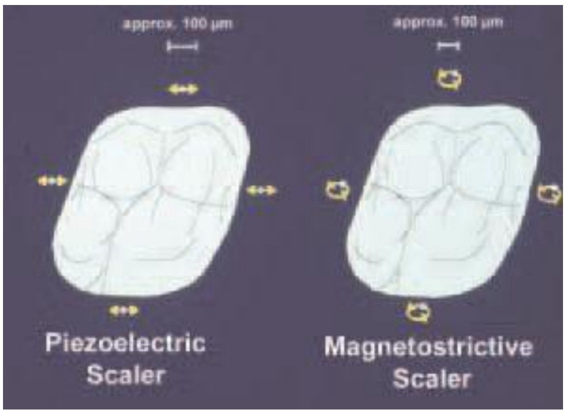

Figure 3. *Schematic difference between piezoelectric and magnetostrictive scaler*

Several researchers have compared these two types of ultrasonic scalers. Yousefimanesh et al. reported that piezoelectric scalers produced smoother root surfaces than magnetostrictive scalers when applied under the same force conditions.[15] Similarly, Flemming et al. found that magnetostrictive scalers exerted a more aggressive effect on root surfaces compared to piezoelectric units.[25]

Periodontal disease cases frequently accompanied by gingival recession often results in exposed dentin. When dentin becomes exposed, it is more susceptible to external stimuli. If a large number of dentinal tubules are open and lead directly to the pulp, dentin hypersensitivity frequently occurs.[26] Dentin hypersensitivity is defined as a short, sharp pain resulting from exposed dentin in response to thermal, evaporative, tactile, or osmotic stimuli.[27] Among these, cold stimulation is considered the most potent trigger of hypersensitivity.[28] Magnetostrictive ultrasonic scalers can be considered with caution in such cases, as they generate more heat than piezoelectric devices and thus require twice the amount of water irrigation to maintain a safe intraoral temperature. In contrast, piezoelectric scalers can be operated with pre-warmed irrigation water, offering a potential advantage in patient comfort.[29]

A study by Daly et al. demonstrated no significant difference in patient- perceived discomfort between the two types of scalers when used at room temperature. However, patients expressed a preference for piezoelectric scalers with warmed irrigation water due to lower levels of discomfort, reduced noise, and smoother vibrations compared to magnetostrictive scalers.[30] The use of ultrasonic devices in periodontal therapy also has the potential to act as a stimulus for dentin hypersensitivity, particularly in patients with exposed dentin. Even minimal mechanical stimulation on localized areas can trigger a brief, sharp pain due to compression of the dentinal tubules. Moreover, the use of cold water irrigation in ultrasonic scalers can spread over a larger area of exposed dentin, potentially intensifying the pain due to a higher number of open tubules being affected..[21]

4. Conclusion

Both magnetostrictive and piezoelectric ultrasonic scalers are equally effective in non-surgical periodontal therapy, with no significant differences in clinical outcomes. However, variations in their technical characteristics—such as vibration pattern, heat generation, and patient comfort—give each type distinct advantages. Piezoelectric scalers offer greater precision and are generally perceived as more comfortable by patients, while magnetostrictive scalers provide greater flexibility in adapting to varied clinical scenarios.

Therefore, the selection of ultrasonic scaler should be tailored to the individual needs of the patient and the specific clinical context, based on a thorough understanding of the working principles and potential effects on surrounding tissues. This approach helps ensure optimal therapeutic outcomes. Based on the literature reviewed, the authors conclude that piezoelectric ultrasonic scalers with water irrigation may offer superior performance and higher levels of patient comfort in clinical practice.

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