Effectiveness and Efficiency in Ultrasonic Scaling

A Peer-Reviewed Publication
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Educational Objectives
Upon completion of this course, the clinician will be able to do the following:
1. Understand the importance of biofilm and calculus removal
2. Identify the advantages of ultrasonic scalers compared to hand scalers
3. Understand the types of power scalers available, their modes of action, and considerations in selecting a power scaler
4. Be able to determine the clinically appropriate inserts and tips for use in individual cases and the sequence in which these should be used
5. Identify the ergonomic advantages and recent advancements in ultrasonic scalers
6. Understand the types of tips that can be used safely and effectively in implant maintenance, as well as which materials are contraindicated for scaling implants

Abstract
The standard non-surgical treatment for periodontal disease is supra- and subgingival scaling to disrupt and thoroughly remove biofilm, calculus deposits, periodontal pathogens, and debris. Instrumentation options include hand scalers and ultrasonic scalers. Considerations in the choice of method include efficacy, efficiency, safety, patient comfort, and ergonomics. Ultrasonic devices have enabled clinicians to effectively and efficiently remove supragingival and subgingival hard deposits and biofilm. When selected and used appropriately, they are clinician and patient friendly. Scaling inserts have evolved to include slim, complementary tips which are curved right and left, straight, beavertail, and angulated insert tips; as well as specialty instruments, inserts and tips designed for safe and effective implant care without altering the integrity of implants. Instrumentation strategies used in debriding implants must ensure that the instruments are compatible with the implant surface. Plastic scaling instruments and plastic-tipped ultrasonic scalers have been found to be safe and effective to use around implants.

The latest generation of ultrasonic scalers offers the ability to thoroughly instrument deep pockets and furcation areas, and offers benefits over conventional hand scalers which include improved operator ergonomics and comfort, improved patient comfort, less tooth substance removal and more efficient and effective treatment.

Introduction
Periodontal disease relies upon the presence of a mature biofilm rich in periodontopathogens, and is evident to varying degrees in the majority of U.S. adults.1 The progression of periodontal disease is highly variable and dependent largely upon the host response, with bacterial variances between individuals accounting for only 20% of cases progressing.2 Nonetheless, the removal of bacteria and their byproducts is essential to prevent and halt periodontal disease. Home care oral hygiene measures can be effective in removing supragingival biofilm when properly performed. However, once a mature subgingival biofilm has developed, or dental calculus is present, home care is ineffective and clinical care is required. In the absence of clinical intervention, periodontal disease progression in individual patients leads to soft tissue attachment loss and bone loss.

The relationship of biofilm, calculus, and periodontal disease
Within 48 hours of dental biofilm formation, sufficient numbers of periodontopathic anaerobes are established for the onset of gingivitis. If the biofilm is not disrupted, its maturation will result in a complex subgingival biofilm three to twelve weeks after the biofilm starts to form. The subgingival biofilm is highly structured, and contains mainly gram-negative anaerobes.3 Research has found that a small proportion of these anaerobic species form complexes associated with periodontal disease.4 Mature biofilm both harbors and protects bacteria by enveloping them in a well-structured and resistant biofilm. The deepest regions of the biofilm harbor the most periodontopathogens, and are where the highest levels of bacterial vitality are seen.5

The reversible gingivitis which develops 48 hours after the formation of biofilm will transform to an active process whereby the host responds by releasing antibodies, neutrophils, lymphocytes, and macrophages into the adjacent tissue. Interleukin 1 and tumor necrosis factor are cytokines produced by the leukocytes. These inflammatory markers then stimulate the production of matrix metalloproteinases (MMPs). The production of cytokines, prostaglandins, and chemokines leads to inflammation and bone loss.6

Dental calculus is present in the majority of adults supra- and subgingivally, and is 70%-80% inorganic.7 Calculus formation results from calcification of dental biofilm and exfoliated oral epithelial cells. The mineral ions responsible for this originate in the saliva and additionally from the crevicular fluid.8 In addition, dental calculus contains bacterial debris interspersed within a mineral deposit of mainly calcium phosphate (Figure 1). Research has found that supragingival calculus also has nonmineralized areas within it containing bacteria.9 Endotoxins are slowly released from dental calculus10 into the adjacent soft tissue, where they may become destructive to the soft and hard tissues of the periodontium. The disruption and removal of subgingival biofilm and calculus requires clinical intervention, and is typically carried out by non-surgical periodontal treatment.
Goals of non-surgical periodontal treatment

The overall goals of periodontal treatment are to halt disease progression and to obtain clinical attachment gains. Supra- and subgingival scaling are the standard non-surgical treatment for periodontal disease, and may be supplemented with systemic or local antimicrobial therapy or other adjunctive therapy. The objectives of scaling are to disrupt the dental biofilm and to remove the maximum possible amount of dental biofilm, dental calculus, periodontal bacteria, and debris from the root surfaces and soft tissue. A further objective is that the root surfaces be biocompatibly smooth upon completion of scaling, thereby reducing the risk of recolonization and subgingival biofilm adhesion and retention on biocompatible surfaces. (As clarification – root planing is not indicated, and is both clinically unnecessary and damaging to the root surface integrity.) Clinically, definitive removal of dental calculus is important. Retained dental calculus provides a distinct raised or rough site for the adhesion of bacteria and for biofilm retention, and will also contain endotoxins. While it has been suggested that removal of dental calculus may not be key in periodontal treatment, based upon the potential impact of retained or residual dental calculus this is not justified. As with dental biofilm, the objective is thorough removal (Figure 2).

Supra- and subgingival scaling can be performed with hand instruments or with power scalers. An alternative is a blended procedure combining the use of both hand instruments and power scalers. Considerations in the choice of method include efficacy, efficiency, safety, patient comfort, and ergonomics. The use of hand scalers requires great care to achieve a satisfactory result, and takes a considerable amount of time. It is now generally held that hand scalers and ultrasonic scalers are similar in their effectiveness in removing subgingival biofilm. However, standard Gracey curettes are known to be too wide to enter the furcation in more than half of all maxillary and mandibular first molars, which have furcation entrances as narrow as 0.63 mm wide while the minimum width of the Gracey curettes is 0.76 mm. Hand scalers have been found to be ineffective in removing calculus deposits in furcation areas whether an open- or closed-flap technique is used. Ultrasonic scalers are considered superior to hand instruments for the treatment of moderate and severe furcations. The precision thin tips of ultrasonic scalers are significantly thinner than the working end curettes, enabling them to enter narrow furcation areas. A further difference exists between hand scalers and ultrasonic scalers with respect to their positioning for calculus removal (Figure 3). In the case of hand scalers such

Figure 1. Dental Calculus Formation

Figure 2. Goals of Non-Surgical Periodontal Treatment
as curettes, the scalers must be apical to the deposit prior to its removal, while with ultrasonic scalers the insert is positioned coronal to the deposit20 – resulting in easier application of the instrument and potentially less tissue distension. It has also been found that hand instruments appear to cause more root surface damage than ultrasonic scalers used at a medium power setting.21 Jacobson et al. found that using hand scalers resulted in grooves and cementum removal evident with SEM analysis, while the use of ultrasonic scalers resulted in no detectable changes to the root surface.22 Most recently, lasers have also been used for scaling and root planing procedures. Clinical results using lasers have been variable, and while effective in removing calculus deposits, in vitro testing found the Er:YAG laser to be less efficient than ultrasonic scalers and the lased root surface was found to be structurally altered with the development of a surface microroughness after lasing.23

Hand instrumentation requires highly repetitive, intricate, and complex hand movements, which can be wearing and ergonomically unsatisfactory. Ultrasonic devices have enabled clinicians to effectively and efficiently remove hard deposits and subgingival biofilm. When selected and used appropriately, they are also clinician and patient friendly, and offer ergonomic benefits over hand scaling. Ultrasonic scaling also reduces the time required for thorough scaling compared to hand scaling, increasing efficiency for the office by reducing the time patients must sit in the dental chair.

**Types of ultrasonic scaling devices**

Ultrasonic scalers have been in use since the 1950s, when the first stand-alone ultrasonic scalers were introduced. Since then they have been revolutionized with the introduction of ergonomically designed devices and tips, microtips, microprocessor controls, and other innovations. Ultrasonic devices are available in the U.S. as magnetostrictive devices and as piezoelectric devices (Figure 4).

These are mechanically distinct in their mode of action and method of use. In the U.S., the best known and most used is the magnetostrictive ultrasonic scaler.

<table>
<thead>
<tr>
<th>Minimum width of tips</th>
<th>Hand Scalers</th>
<th>Ultrasonic Scalers</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.76 mm</td>
<td>0.55 mm</td>
<td></td>
</tr>
<tr>
<td>Slim inserts available</td>
<td>Yes - less slim than ultrasonic slim tips</td>
<td>Yes</td>
</tr>
<tr>
<td>Positioning of tips</td>
<td>Apical to the deposit</td>
<td>Coronal to the deposit</td>
</tr>
<tr>
<td>Deposit removal in furcations</td>
<td>Less effective</td>
<td>More effective</td>
</tr>
<tr>
<td>Lavage</td>
<td>None</td>
<td>Low to moderate</td>
</tr>
<tr>
<td>Patient comfort</td>
<td>Varies with clinical skill, tips used</td>
<td>Varies with clinical skill, tips used</td>
</tr>
<tr>
<td>Root surface damage</td>
<td>More than with ultrasonic scalers</td>
<td>Less than with hand scalers</td>
</tr>
<tr>
<td>Ergonomics</td>
<td>More wearing, fatigue</td>
<td>Less wearing, fatigue</td>
</tr>
<tr>
<td>Bacterial aerosol</td>
<td>If irrigation is used</td>
<td>Yes, minimize</td>
</tr>
</tbody>
</table>

**Magnetostrictive ultrasonic scalers** rely upon an elliptical movement of the ultrasonic tip. The magnetostrictive stack in the insert converts energy from the handpiece into mechanical oscillations that activate the insert tip (Figure 5). The electronic system produces small strokes of the insert that are microscopic and delivers from 25,000 to over 40,000 cycles (strokes) per second at the tip. A second type of magnetostrictive device that is less common (Odontoson) uses a ferrite rod to produce a rotational rather than elliptical movement. Ultrasonic devices are available with closed loops that automatically adjust the tuning for the resonance of each tip, enabling the clinician to successively insert different tips into the handpiece without having to stop and adjust settings each time.

When using magnetostrictive scalers, the insert must be meticulously adapted to all areas of the tooth surface. It is important to note that the most active area of the insert’s tip is the point, followed by the concave face of the insert, then the convex back, with the lateral surfaces
being the least active. The point of the insert should never be directed into the tooth surface, and care should be taken that the face of the insert is not adapted perpendicular to the tooth’s surface. The majority of scaling will be accomplished with the back and lateral surfaces of the insert. The length of the active tip area for scaling depends upon the energy output and frequency at which the ultrasonic unit operates. Magnetostrictive ultrasonic scalers operate at a frequency ranging from 18 to 45 kHz, typically at 25 or 30 kHz. At a frequency of 25 kHz, the terminal 4.3 mm of the tip is active, at 30 kHz 4.2 mm of the tip is active (Figure 6, 7). A higher frequency of 50 kHz results in an active area in the terminal 2.3 mm of the tip.24 The inserts should be activated prior to insertion into the pockets and used with a continual stroking motion in a horizontal, vertical, or oblique manner – offering the clinician flexibility and choice. It is important to keep the tip moving and to maintain the integrity of the contact between the active area of the tip and the tooth surface for optimal results. Other important factors in tip use are the amount of lateral force applied – which should be light – and the angulations of the tips themselves to ensure that they are maintained against the tooth surface. Magnetostrictive technology results in all surfaces of the insert being active. Since all four surfaces of the inserts are active and used for scaling, magnetostrictive ultrasonic technology offers more flexibility in adaptation to the tooth surface as well as ease of use and more flexibility in technique.

The thoroughness with which scaling devices are used is a key attribute for success. If the insert is applied incorrectly to remove biofilm and calculus, the tooth surface may be damaged. As with hand instruments, if inserts are not used properly the removal of biofilm and calculus will not be definitive and will compromise the clinical results and the achievement of the goals of therapy. Studies have shown that in comparing a sonic instrument (Periosonic), magnetostrictive ultrasonic (Cavitron®, Slimline inserts), and hand curettes that all three were effective in disrupting biofilm and in removing biofilm and calculus deposits. It was found that use of the magnetostrictive ultrasonic scaler resulted in the least tooth substance loss.25 It is well recognized that residual calculus is difficult to detect, with false negatives being commonplace – one study estimated that 77% of surfaces with residual calculus had been scored as calculus-free.26 Regardless of the type of instrumentation used, this can occur and is also dependant upon individual clinical expertise. To ensure that calculus is removed and that it is not burnished, it is important to select appropriate tips and to use the correct power setting based on patient need. Magnetostrictive ultrasonic units are available that are designed to definitively remove calculus at low to moderate power settings, and some incorporate a power booster which can momentarily increase the power by up to 25% without further altering the device’s settings. These features result in thorough re-

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**Figure 5. Magnetostrictive Ultrasonic Insert**

Stack movement results in lengthening and shortening of the insert, and an elliptical pattern movement of the active tip.

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**Figure 6. Active Tip Area and Ultrasonic Scaler Frequency**

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Active Tip</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 kHz</td>
<td>Terminal 4.3 mm</td>
</tr>
<tr>
<td>30 kHz</td>
<td>Terminal 4.2 mm</td>
</tr>
<tr>
<td>50 kHz</td>
<td>Terminal 2.3 mm</td>
</tr>
</tbody>
</table>

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**Figure 7. Ultrasonic Insert Design and Active Tip Terminal**
removal of biofilm and calculus deposits, while increasing patient comfort and ergonomics for the clinician.

**Piezoelectric ultrasonic scalers** rely upon linear movement. The piezoelectric device uses aligned ceramic discs to produce the straight micromovements of the tip through alternating expansion and compression of the ceramic discs when electricity flows over the surfaces of the crystal (Figure 8). Piezoelectric ultrasonic units operate at a frequency ranging from 25 to 50 kHz. Given the linear fashion in which the tip moves, with piezoelectric devices the tip’s two lateral surfaces are most active. If adaptation to the tooth’s surface is incorrect the tip will sound different against the tooth, letting the clinician know that the tip adaptation needs to be altered. Deposit removal should be accomplished by utilizing the lateral surfaces of a piezoelectric insert. Clinicians must develop definitive techniques to maximize efficiency. The tip must be held lateral to the tooth surface, which is often achieved by pivoting the wrist. While clinical results are similar to those obtained with the use of magnetostrictive devices, the limitations of active surfaces afforded by a piezoelectric scaler make it a much more technique-sensitive device. Without successful technique, the clinical outcome of piezoelectric scaling may be compromised – potentially resulting in root surface damage and incomplete deposit removal. In the same vein, clinicians using magnetostrictive units should take care not to limit their instrumentation to the instrument’s lateral surfaces.

**Comparison of Magnetostrictive and Piezoelectric Ultrasonic Units**

The use of either magnetostrictive or piezoelectric ultrasonics requires great care and an overlapping movement around the whole of the root surface to ensure biofilm and calculus removal. One in vitro study comparing ultrasonic scalers and hand curettes found while the piezoelectric device resulted in slightly faster instrumentation compared to the magnetostrictive device, both were more efficient than hand curettes. In measuring the tooth surface roughness (Ra), however, the tooth surface was smoothest after use of the magnetostrictive device and roughest following use of the piezoelectric device. In comparing all three instrumentation methods, the hand curette produced the smoothest surface but the most tooth substance loss as measured by SEMs, and the magnetostrictive produced the least tooth substance loss.27 The efficacy of calculus removal from a root surface was found to be the same with all three methods.

In comparing magnetostrictive and piezoelectric devices, it has been suggested that piezoelectric devices may be more comfortable for patients28 due to their linear rather than elliptical movement. However, for both devices the adaptation of tips at the correct angle and

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**Figure 8. Piezoelectric Ultrasonic Insert**

Crystal action of piezo results in a lateral movement of the active tip.

**Figure 9. Comparison of Magnetostrictive and Piezoelectric Ultrasonic Units**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Magnetostrictive Units</th>
<th>Piezoelectric Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanism</td>
<td>Metal stack or ferrite rod</td>
<td>Aligned ceramic discs</td>
</tr>
<tr>
<td>Tip Movement</td>
<td>Elliptical</td>
<td>Linear</td>
</tr>
<tr>
<td>Active Surfaces</td>
<td>Back, face, and lateral (4)</td>
<td>Lateral (2)</td>
</tr>
<tr>
<td>Positioning of Tips</td>
<td>Flexible</td>
<td>Must be lateral to surface</td>
</tr>
<tr>
<td>Slim Inserts Available</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Inserts that Mimic Perio Probe</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Effective Calculus Removal</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Coolant/Lavage Volume</td>
<td>Low to high, directional with some inserts</td>
<td>Low to moderate</td>
</tr>
<tr>
<td>Patient Comfort</td>
<td>Varies with clinical skill, tips used</td>
<td>Varies with clinical skill, tips used</td>
</tr>
<tr>
<td>Technique Sensitive</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td>Learning Curve</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td>Flexibility of Technique</td>
<td>+++</td>
<td>+</td>
</tr>
</tbody>
</table>
keeping the tip in motion when against the tooth helps prevent discomfort. In this regard, adaptation is more versatile with the magnetostrictive ultrasonic inserts, which are active on four rather than two surfaces (Figure 9). Similarly, it is important to use only a very light grasp and pressure. One study compared pain perception in patients treated with either a magnetostrictive ultrasonic unit (Dentsply) or a piezoelectric unit (Vector). The patients’ perception of pain was similar during and after treatment, irrespective of the ultrasonic unit used. It should be noted that pain may be associated with tissue distension/manipulation or dentinal hypersensitivity rather than with the movement of ultrasonic tips. Tissue distension can be minimized through careful selection of tips and technique (Figure 10). Where unavoidable, the use of locally delivered topical anesthetics (Oraqix, Dentsply) or local anesthetics may be necessary, and peri-operative use of desensitizing agents helps relieve hypersensitivity during treatment.

The cavitational effect of ultrasonic devices aids biofilm removal, and the acoustic effects of the water lavage assist in the removal of calculus deposits. Similarly, the lavage obtained from power-driven scalers’ water/fluid coolant provides for continual flushing and is believed to be of therapeutic benefit. While lavage is considered beneficial, a balance is desirable between no lavage and lavage that is copious and non-directional. With overzealous lavage, the potential for patient gagging and patient discomfort increases and a longer treatment time is required as the amount of suctioning necessary increases. This may result in the clinician having to stop while suction is used to evacuate the water or chemotherapeutic used for lavage. Generally, piezoelectric ultrasonic units use less water than magnetostrictive ultrasonic units. To decrease the fluid necessary for proper lavage production, innovations in magnetostrictive insert designs have allowed for a more focused spray with minimal fluid volume. It is possible to use a focused spray or drip of water delivered through the insert and tip itself—enabling better visibility, more directional control, increased patient comfort and a decreased need for suction while still providing the beneficial effects of lavage.

**Ultrasonic tip and insert designs**

Originally, ultrasonic tips were available only with extremely limited design options. By the 1990s clinicians and manufacturers recognized the clinical limitations of the bulky tip options on the market and a line of magnetostrictive inserts designed to improve subgingival and furcation access was introduced. Slim tip inserts are designed to be approximately 30% slimmer than standard inserts. The smaller profile of the revised tips not only resulted in improved access—in particular to the depths of pockets greater than 4 mm depth—but also provided improved patient comfort by reducing tissue manipulation and distension.

In one study in the early 1990s, hand instruments failed to adequately reach the base of deep pockets on 75% of root surfaces, primarily due to the impediments imposed by pocket morphology, yet the base of deep pockets is exactly where higher levels of periodontal pathogens are found. Slim tips available for both magnetostrictive and piezoelectric ultrasonic units are designed to reach into deep pockets effectively and safely. They are able to improve pocket access by 1 mm over hand instrumentation, and to reach the base of 86% of pockets 3 to 6 mm deep. Slim tips designed to mimic the ends of periodontal probes enable easier insertion and improved tactility. This enables detection of remaining or residual calculus, saving time by decreasing instrument exchange during treatment.

When compared to the original cumbersome tip designs, the slimmer inserts decrease the amount of tooth surface that is lost to instrumentation. In one study, slim scaler tips were found to produce less substance loss for both magnetostrictive slim tips (Slimline) and

**Figure 10. Slim Tip Insert Provides Ease of Access Into Pocket and Minimizes Tissue Distension**

**Figure 11. Dentin Loss Using Slim Tips: MR and PZE**

<table>
<thead>
<tr>
<th></th>
<th>Slim Tips (MR unit)</th>
<th>Slim Tips (PZE unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width (in microns)</td>
<td>254.4</td>
<td>352</td>
</tr>
<tr>
<td>Depth (in microns)</td>
<td>6.3</td>
<td>12.1</td>
</tr>
<tr>
<td>Volume (in cubic microns)</td>
<td>22.5</td>
<td>56.4</td>
</tr>
</tbody>
</table>
piezoelectric slim tips (Perioprobe). In comparing the slim scaler tips of both types of devices, dentin loss was assessed using laser profilometry for depth, width, and volume of defects. The magetostrictive device resulted in less gouging than the piezoelectric device, with mean changes in the dentin of 254.4 microns, 6.3 microns and 22.5 cubic microns for width, depth and volume versus 352.0 microns, 12.1 microns and 56.4 cubic microns respectively (Figure 11). It was also found that for both devices, changing the force used from 0.3N to 0.7N increased the substance loss twofold, underscoring the importance of using a light to moderate instrumentation force.

Flemmig et al. studied slim inserts using a piezoelectric ultrasonic scaler and compared instrumentation using varying angulations, lateral forces, various power settings, and instrumentation time. It was found that lateral force most influenced the total amount of root substance loss, while tip angulation had the most effect on the depth of the defect, with the greatest defect depth and volume loss occurring when the angulation of instrumentation measured was 45 degrees with 2N lateral force applied. The study concluded that “to prevent severe root damage it is crucial to use the assessed scaler at a tip angulation of close to 0 degrees”. In a separate study assessing root substance loss when slim tips were used in magetostrictive ultrasonic units, Flemmig et al. again found that the greatest influence on the volume of tooth surface lost to improper instrumentation was the lateral force applied. Angulations of 0, 45, and 90 degrees were used. Unlike the results in the piezoelectric study, severe root damage was not evident when the angulation was 45 degrees, 0.5N lateral force, and the power was set at up to a medium setting. This study concluded that “the efficacy of the assessed magnetostrictive ultrasonic scaler may be adapted to the various clinical needs by adjusting the lateral force, tip angulation, and power setting.”

As ultrasonics have evolved, new designs in straight and curved tips have also included complementary designs reflecting the site-specific benefits of Gracey curettes (Figure 12). By using both right and left inserts in deeper pockets (>4 mm deep) the full circumference of the root, complex root anatomy and furcations can be more easily and properly instrumented (Figure 13). Right and left tip inserts are designed to adapt to the root surface and furcation areas for optimal results, with each of these used in specific areas of the mouth and teeth – similar to Gracey curettes. When entering the furcation, rotating the insert enables the tip to reach the roof of the furcation (Figure 14).

The importance of superior access and adaptation cannot be underestimated in deep pockets or furcations. Furcation involvement is a leading cause of periodontally-induced tooth loss, and periodontal treatment failure for molars with furcation involvement is more than double the rate of treatment failure for molars with no furcation involvement over an eight-year period. At their narrowest point, the roof of furcations can be narrower than the width of hand instruments, making them inaccessible or extremely difficult to instrument.

Other insert tips include diamond-coated ultrasonic tips. Some manufacturers have designed and advocate diamond-coated tips for non-surgical scaling. Other manufacturers advocate these tips specifically for difficult-to-remove calculus during open-flap procedures, and not for use with non-surgical scaling. Incorrect use of diamond-coated ultrasonic tips can lead to tooth substance loss and soft tissue damage. Teflon-coated tips have been tested.
and, while effective in disrupting and removing biofilm, were found to be less effective in removing calculus than conventional ultrasonic tips.  

**Instrumentation sequence**
Just as with hand instruments, different ultrasonic inserts are designed for specific tasks (Figure 15). Standard ultrasonic inserts are designed for moderate to heavy deposit removal, and slim inserts are designed for light deposit removal. Standard inserts are not intended for use in deep pockets nor are they designed for root adaptation in deep pockets, and should not be regarded as a universal insert. Utilizing the appropriate ultrasonic inserts in the correct sequence and at the appropriate power level ensures good clinical results and comfort for the patient and an ergonomic dental hygiene procedure (Figures 16, 17). In general, supragingival calculus deposits should be removed using a standard diameter insert at a low to high power setting as indicated by the patient’s oral condition. Following use of standard diameter inserts, debridement of pockets 4 mm deep or greater is achieved using slim tipped inserts at a low power setting. Recent magnetostrictive innovations allow use of lower power settings for thorough calculus debridement. The final stage of the scaling procedure is the use of a slim insert at a low power setting to remove the smear layer on the root surface.

**Chemotherapeutic irrigants for lavage**
Water is routinely used in ultrasonic units as a coolant and has a lavage effect in the periodontal pockets. The use of chemotherapeutics with ultrasonic inserts offers lavage and cooling of the insert tip with the additional benefit of placing the chemotherapeutic agent directly into the periodontal pocket during the scaling procedure. Over the years, various chemotherapeutic agents have been used, including chlorhexidine, povidone-iodine and sodium hypochlorite. An early study comparing use of 0.12% chlorhexidine gluconate and sterile water for

### Figure 15. Insert Tips and Function

<table>
<thead>
<tr>
<th>Scaler Insert Tip</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>Removal of moderate-heavy deposits</td>
</tr>
<tr>
<td>Standard triple-bend</td>
<td>Aids access for removal of moderate-heavy deposits</td>
</tr>
<tr>
<td>Beavertail</td>
<td>Removal of heavy deposits and stains; anterior teeth</td>
</tr>
<tr>
<td>Chisel</td>
<td>Anterior teeth and premolars; overhanging margins</td>
</tr>
<tr>
<td>Perio probe</td>
<td>Shallow and deep pocket deposit removal;</td>
</tr>
<tr>
<td></td>
<td>Deeper subgingival lavage; calculus detection</td>
</tr>
<tr>
<td>Slim tips</td>
<td>Deposit removal in pockets 4 mm deep and greater</td>
</tr>
<tr>
<td>Straight</td>
<td>Superficial deposit removal</td>
</tr>
<tr>
<td>Curved and angulated</td>
<td>Aid access and adaptation</td>
</tr>
<tr>
<td>Curved right and left</td>
<td>Aid access and adaptation to root morphology; furcation areas</td>
</tr>
<tr>
<td>Right and left furcation</td>
<td>Deposit removal in root furcation areas</td>
</tr>
<tr>
<td>Fine-tipped</td>
<td>Aid access for deposit removal in narrow interdental spaces</td>
</tr>
<tr>
<td>Diamond-coated</td>
<td>Depends upon manufacturer -</td>
</tr>
<tr>
<td></td>
<td>Gross deposit removal; Surgical or non-surgical access</td>
</tr>
<tr>
<td></td>
<td>Removal of overhanging margins</td>
</tr>
<tr>
<td>Endodontic</td>
<td>Debridement of canals; removal of fractured endodontic instruments</td>
</tr>
</tbody>
</table>

### Figure 16. Sequence for Instrumentation

- **Standard Inserts**
  - Removal of gross, superficial deposits
  - Suitable for pockets up to 3 mm deep
  - Medium-high power setting

- **Slim Tip Inserts**
  - Debridement of pockets 4 mm and deeper
  - Lower power setting
  - +/- hand instrumentation

- **Slim Tip Inserts**
  - Removal of smear layer from root surface
  - Low power setting
cooling and lavage found that the use of chlorhexidine gluconate was beneficial in reducing clinical probing depth 14 and 28 days post-scaling in pockets that were initially 4–6 mm probing depth, but otherwise produced clinically comparable results to the use of sterile water. A second study found that use of chlorhexidine as the coolant resulted in significantly more sites with final probing depths of 1–3 mm, rather than greater than 3 mm with use of water as the coolant. Chlorhexidine coolant was found in this study to have a slight adjunctive effect. A more recent study found that use of chlorhexidine (Eludril) or sodium hypochlorite as an irrigant during scaling and root planing resulted in slightly more effective reduction in plaque index, gingival index, and bleeding upon probing compared to water, with the chlorhexidine being more effective than the sodium hypochlorite. Probing depth reductions, however, were found to be the same as with scaling alone. Research has also been conducted using povidone iodine, with the results suggesting that use of 10% povidone iodine as an irrigant at the time of scaling was effective in reducing the total count of periodontopathic bacteria and could be a useful irrigant during therapy. It is important to note, however, that use of chemotherapeutics as irrigants during ultrasonic scaling is not a substitute for indicated adjunctive antimicrobial treatment such as locally-delivered sustained release agents and has not been shown to have a long-term effect. It has also been found that adjunctive daily use of chemotherapeutic irrigants at home may help reduce inflammation. Another practice is to use water as a coolant during primary scaling, followed by use of a chemotherapeutic during the final phase of scaling and desmearing. It has been suggested that the use of chlorhexidine for lavage will reduce the bacterial count in the aerosol associated with ultrasonic scaling; however, studies indicate that the most important factors in controlling the bacterial aerosol are the use of appropriate suction and an ultrasonic unit utilizing sufficient but modest amounts of coolant delivered directionally to the site.

**Ergonomics**

The primary objective of ergonomics is to prevent work-related injuries. Dental procedures by their nature expose clinicians to occupational health risks. Dental hygiene procedures use particularly repetitive and physically-demanding movements. Occupational risks specific to delivering dental hygiene care include reduced tactile sensitivity, carpal tunnel syndrome, neck and back injuries, and hand and finger injuries due to muscle fatigue. Scaling involves pinch-grasp, force, vibratory stimuli (if ultrasonic scalers are used), and potentially awkward operator positions that can all result in work-related musculoskeletal injuries.
Scaling ergonomically requires a number of considerations. Selecting a position for the patient that is comfortable for clinician and patient alike – usually seating the patient at a 45-degree angle – is the first step; this angle should be adjusted as necessary. Similarly, instead of a clinician bending his or her neck and back, it is important to have the patient turn his or her head to the right or left and chin up or down to improve access and visibility to awkward areas (Figure 18). Contrary to instinct, taking the time to have patients do so will save time and result in less fatigue and wear for the clinician without compromising the patient’s comfort or the outcome.

The use of finger rests or fulcrum points helps reduce the thumb pinch force and reduces hand muscle load while utilizing hand instruments. Extra-oral and/or hand-on-hand fulcrums are recommended with ultrasonics to assist with flexibility of movement. Beyond these simple steps, the ergonomics of scaling is mostly influenced by technique and instrument selection.

When hand scaling, it has been demonstrated that dental hygienists reduce their tactile sensitivity in as little as 45 minutes. In contrast, in dental hygienists using ultrasonic scalers tactile sensitivity increased and vibration was insufficient to reduce tactile sensitivity. Handle instrument design influences hand muscle load and pinch force. Lightweight hand instruments with larger-diameter handles have been found to reduce muscle load and pinch force when compared to heavy or thin-handled instruments. Handle design also influences selection of ultrasonic inserts and tips. Thicker handle insert designs that incorporate a thick, soft, and dimpled rubber-like handle on the insert are available to improve clinician comfort (Figure 19).

Softer and fatter grips also enable easier rotation and reduce hand fatigue. These handle innovations do not reduce or affect the wrist pivot required to position tips properly during piezoelectric instrumentation. Originally, ultrasonic handpieces were static and did not pivot during instrumentation. Currently, magnetostrictive units are available with handpieces with swivel features, which reduce discomfort, minimize line pinching, and enable instrument manipulation in areas of difficult access (such as furcations and distal root areas). Recent innovations in magnetostrictive ultrasonic units include the incorporation of a remote frequency wireless foot control. This technology enables the foot control position more flexibility, since...
it is not tied to the unit by a cord, and also operate from any side of the base. This offers ease of use and ergonomic benefits since the clinician can position the foot control in the most comfortable position without needing to consider any cords (Figure 20).

**Implant care**

As dental implants continue to evolve into a routine dental procedure, the need for improved scaling instruments and devices is increasing. Long-term implant failure due to peri-implantitis occurs commonly in patients with poor oral hygiene and who do not attend periodic maintenance visits. Initially, biofilm formation will result in peri-mucositis that is etiologically similar to gingivitis in the natural dentition. If improved oral hygiene procedures and professional maintenance care are not initiated, this will progress to irreversible peri-implantitis – inflammation of the tissue at the implant site, with both soft tissue inflammation and bone loss. Infected implant sites have six times the number of gram-negative anaerobes compared to gram-positive aerobes. Meticulous home care and regular clinical maintenance visits are essential to prevent peri-implantitis. Inflammation of the implant site must be kept to a minimum through soft and hard tissue deposit removal while minimally impacting the surrounding tissues and the implant. This includes the removal of biofilm and calcified deposits at the implant site and on the implant surface. Instrumentation strategies used in cleaning implant(s) must ensure that the instruments used are compatible with the implant surface. Implant damage due to inappropriate instrumentation increases the likelihood of biofilm formation and maturation, anaerobic colonization, and calculus formation.

Metal tip hand scalers, including titanium alloy and stainless steel curettes, and metal ultrasonic tips, have been found in studies to result in implant surface roughness and to increase the surface roughness of titanium abutments. In addition to considerations regarding the use of metal scalers, it has also been found that HA-coated and plasma-coated implants are susceptible to surface alterations during scaling and more so than non-coated implants (Figure 21).

Plastic scaling instruments have been found to be safe for use around implants and abutments, and not to increase the surface roughness of the titanium. Plastic-tipped ultrasonic scalers are effective and safe. Plastic-tipped ultrasonic scalers are effective and safe. In vitro research using scanning electron microscopy found that use of disposable plastic tips over metal base tips left virtually no traces and did not destroy the surface integrity of implants and abutments. Systems are available that use metal bases on specialty ultrasonic inserts with a single-use soft plastic tip that fits over the metal base (Cavitron® SofTip™, Dentsply Professional) (Figure 22). These plastic tips are designed to effectively remove biofilm and light calculus deposits at implant sites as well as on the implants.
and superstructures, without damaging the implant’s surface or affecting the integrity of the peri-implant mucosal cuff.

Summary
Research over the last two decades has resulted in new insights into periodontal disease. While it is the host response that is generally responsible for the progression of periodontal disease, gram-negative bacteria found in mature biofilm are essential for periodontal disease to exist and progress. The standard non-surgical treatment for periodontal disease is supra- and subgingival scaling to disrupt and thoroughly remove biofilm, calculus deposits, periodontal pathogens, and debris. Instrumentation options include hand scalers and ultrasonic scalers. Ultrasonic scalers available in the U.S. include both magnetostrictive and piezoelectric units, with the magnetostrictive ultrasonic unit being more frequently used. Scaling inserts have evolved to include slim, complimentary curved right and left, straight, beavertail and angulated insert tips as well as specialty instruments, inserts, and tips designed for safe and effective implant care without altering the integrity of implants. The latest generation of ultrasonic scalers offers the ability to thoroughly instrument deep pockets and furcation areas, and offers benefits over conventional hand scalers including improved operator ergonomics and comfort, improved patient comfort, as well as more efficient and more effective treatment.

Acknowledgement
Biofilm image courtesy of Dr. Gary Carr, Pacific Endodontic Research Foundation.

References


Author Profile

Elizabeth (“Betsy”) Reynolds, RDH, MS

Ms. Betsy Reynolds has been a practicing hygienist for over twenty years and has been involved with several private practices stressing comprehensive periodontal care for patients seeking treatment. Betsy has reinforced her love of the microbiological aspects of periodontal therapy by maintaining teaching positions emphasizing the dental sciences at numerous dental and dental hygiene schools.

Betsy lectures extensively nationally and internationally on subjects that include biologic basis for disease prevention, advanced instrumentation technique, current dental therapeutic modalities, pharmacological considerations for the dental professional, microbiological and immunological aspects of dental disease, the impact of oral disease on systemic health, evidenced-based decision-making and scientific developments affecting oral health care delivery. Additionally, she has authored numerous articles and book chapters on a variety of oral healthcare concerns. Betsy holds a Master of Science Degree in Oral Biology from the University of Washington.

Living in Boise, Idaho amidst the beauty of the Rocky Mountains and the magnificent untamed waters of the Salmon River, Betsy enjoys spending time outdoors with her husband, Mike, and their two dogs, Lucy and Nellie.

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Questions

1. The removal of _____ is essential to halt and prevent periodontal disease.
   a. Bacteria
   b. Pellicle
   c. Crevicular fluid
   d. None of the above

2. Interleukin 1 is a _____ produced by leukocytes.
   a. Enzyme
   b. Cytokine
   c. Prostaglandin
   d. None of the above

3. Dental calculus contains calcified_____.
   a. Biofilm
   b. Exfoliated oral epithelial cells
   c. Saliva
   d. a and b

4. Subgingival calculus is typically removed by _____.
   a. Brushing
   b. Non-surgical periodontal treatment
   c. Subgingival irrigation
   d. None of the above

5. Overall goals of non-surgical periodontal treatment are _____.
   a. To halt disease progression
   b. To reduce bleeding
   c. To obtain clinical attachment gains
   d. a and c

6. Hand scalers have been found to be ineffective in removing calculus in _____.
   a. Narrow interproximal areas
   b. Furcation areas
   c. Mesial root surfaces
   d. All of the above

7. Furcation entrances can be as narrow as _____.
   a. 0.45 mm
   b. 0.63 mm
   c. 0.75 mm
   d. 0.92 mm

8. Ultrasonic scalers are considered superior to hand scalers in _____ furcations.
   a. All
   b. Moderate and severe
   c. Wider
   d. No

9. Ultrasonic scalers are available as _____.
   a. Magnetostrictive units
   b. Piezoelectric units
   c. Supersonic units
   d. a and b

10. Elliptical movement is obtained using a _____ ultrasonic device.
    a. Piezoelectric
    b. Piezomechanical
    c. Magnetostrictive
    d. a and c

11. Magnetostrictive ultrasonic units can use a _____ to convert energy.
    a. Stack
    b. Cell
    c. Ferrite rod
    d. a and c

12. Piezoelectric ultrasonic units use _____ to convert energy.
    a. Ceramic rods
    b. Ceramic discs
    c. Metallic discs
    d. Any of the above

13. The majority of scaling using magnetostrictive ultrasonic inserts will be accomplished with ____________.
    a. The point
    b. The face
    c. The lateral and convex back surfaces
    d. The face and lateral surfaces

14. The available active area in the terminal part of ultrasonic inserts depends upon _____.
    a. The frequency at which the ultrasonic scaler operates
    b. The length of the insert
    c. The force applied using the insert against the tooth
    d. None of the above

15. Slim tip inserts are designed to be approximately _____ than standard inserts.
    a. 20% slimmer
    b. 30% slimmer
    c. 15% shorter
    d. None of the above

16. What part of the insert should never be directed at the tooth surface?
    a. The lateral surface
    b. The tip
    c. The point of the tip
    d. The circumference

17. Important factors in tip use are _____.
    a. Keeping the tip moving continually
    b. Applying a light lateral force
    c. Angulations of the tips to ensure they are against the tooth surface
    d. All of the above

18. False negatives for the presence of residual calculus have been found in up to _____ of root surfaces.
    a. 45 percent
    b. 55 percent
    c. 77 percent
    d. 83 percent

19. Piezoelectric ultrasonic units rely upon what type of movement?
    a. Rotational
    b. Elliptical
    c. Linear
    d. All of the above

20. With piezoelectric ultrasonic units, _____ surfaces of the insert’s tip are the most active.
    a. All
    b. The lateral
    c. The front and back
    d. Only the back
Questions

21. Hand curettes have been found to be less efficient in scaling procedures than _____.
   a. Irrigation
   b. Magnetostrictive ultrasonic scalers
   c. Piezoelectric ultrasonic scalers
   d. b and c

22. In a study comparing magnetostrictive and piezoelectric ultrasonic scaling, patients’ perception of discomfort was found to be _____.
   a. Similar
   b. Very different
   c. Less with piezoelectric ultrasonic scaling
   d. Less with magnetostrictive ultrasonic scaling

23. Tissue distension can be minimized through _____.
   a. Technique
   b. Careful selection of tips
   c. a and b
   d. Local anesthesia

24. The cavitation effect of ultrasonic scalers aids _____.
   a. Biofilm removal
   b. Bacterial resistance
   c. Saliva production
   d. a and b

25. Reducing the amount of water sprayed from inserts _____.
   a. Improves visibility
   b. Improves patient comfort
   c. Reduces the need for suction
   d. All of the above

26. Patient comfort varies with _____.
   a. The specific insert tips used
   b. Clinical skill
   c. The patient’s ability to sit upright
   d. a and b

27. The flexibility of scaling technique is greatest with _____.
   a. Piezoelectric ultrasonic units
   b. Magnetostrictive ultrasonic units
   c. Lasers
   d. a and b

28. The efficacy of magnetostrictive ultrasonics can be adapted by adjusting _____.
   a. Tip angulation
   b. Lateral force
   c. Power setting
   d. All of the above

29. The full circumference of deep pockets and root morphology can be properly instrumented using _____.
   a. Beavertail inserts
   b. Right and left inserts
   c. Straight inserts
   d. Any of the above

30. Teflon-coated tips have been found to be _____ than conventional ultrasonic tips.
   a. As effective
   b. More effective
   c. Less effective
   d. Quicker

31. Inserts are available for ultrasonic units with _____ tips.
   a. Straight
   b. Angulated
   c. Curved left and right
   d. All of the above

32. Standard size straight ultrasonic inserts are designed for _____.
   a. Moderate to heavy deposit removal in probing depths less than 4 mm
   b. Deposit removal in pockets deeper than 6 mm only
   c. Biofilm removal only
   d. a and b

33. Debridement of pockets 4 mm deep or greater is achieved by _____.
   a. Using straight inserts and a low power setting
   b. Using slim inserts and a high power setting
   c. Using slim inserts and a low power setting
   d. a or b

34. Liquids used for lavage include _____.
   a. Water
   b. Chlorhexidine
   c. Sodium hypochlorite
   d. All of the above

35. Scaling ergonomically includes _____.
   a. Selecting a position for the patient that is comfortable for the clinician
   b. The use of finger rests or fulcrum points
   c. Careful selection of instruments
   d. All of the above

36. Hand muscle load and pinch force are influenced by _____.
   a. The diameter of the handle
   b. The weight of the handle
   c. The positioning of the patient
   d. a and b

37. The use of handpieces with swivel features ________.
   a. Minimizes line pinching
   b. Enables instrument manipulation in areas of difficult access
   c. Restricts patient positioning
   d. a and b

38. Implant surface roughness can result from the use of _____.
   a. Stainless steel curettes
   b. Titanium alloy curettes
   c. Chlorhexidine mouthrinses
   d. a and b

39. Disposable plastic tips designed for specialty implant inserts have been found to _____.
   a. Safely and effectively remove deposits
   b. Disturb the integrity of the implant site
   c. Be ineffective
   d. b and c

40. Compared to hand scalers, benefits of the latest ultrasonic scalers include _____.
   a. Improved patient comfort
   b. Improved operator ergonomics
   c. More effective treatment
   d. All of the above
Effectiveness and Efficiency in Ultrasonic Scaling

Educational Objectives
1. Understand the importance of biofilm and calculus removal
2. Identify the advantages of ultrasonic scalers compared to hand scalers
3. Understand the types of power scalers available, their modes of action, and considerations in selecting a power scaler
4. Be able to determine the clinically appropriate inserts and tips for use in individual cases and the sequence in which these should be used
5. Identify the ergonomic advantages and recent advancements in ultrasonic scalers
6. Understand the types of tips that can be used safely and effectively in implant maintenance, as well as which materials are contraindicated for scaling implants

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