Piezoelectric Ultrasonic Devices and Therapies

General Overview

Together, required and desirable attributes for piezoelectric ultrasonic devices include the ability to offer safe and effective treatment that achieves the best results in the least amount of time, is comfortable for the patient, and is ergonomic for the clinician. In addition, versatility and the availability of a wide range of insert tips is preferable.

Clinically, scaling and root planing is the most frequent indication for piezoelectric ultrasonic devices and, increasingly, ultrasonic scaling using a piezoelectric or magnetostrictive device is being performed alone for this purpose rather than in combination with manual instrumentation. Ultrasonic scaling is as effective as manual scaling, achieving the disruption and removal of biofilm, debris, endotoxins, and dental calculus.[1] This must be thorough to achieve the desired clinical outcomes and the root surfaces must be sufficiently smooth following these procedures to help prevent recolonization and biofilm accumulation. Furthermore, ultrasonic scaling offers several advantages over manual instrumentation including the design of the scaler inserts, access to specific sites, reduction in chairside time, automated irrigation, and ergonomics.

Piezoelectric Scaler Inserts

Piezoelectric scaler inserts are available in numerous configurations for nonsurgical periodontal therapy. Options include inserts with straight and curved insert tips, thin/narrow insert tips, curette-style tips, tips designed specifically for biofilm disruption, diamond-coated tips, and ultrasonic implant scalers constructed of carbon to help avoid iatrogenic damage to implant surfaces at sites being instrumented. Using an ultrasonic device with numerous insert tip configurations means choice—they can be selected based on anatomical and procedural demands, rather than using a universal insert tip. In addition, ultrasonic scaler insert tips are available that are thinner than the thinnest manual scalers (which are too wide to access some furcations), providing improved access to furcations and deep subgingival niches and increasing treatment efficacy.[1,2] Given that treatment failure rates are significantly higher when furcations are present, the ability to access these sites through the use of slimmer ultrasonic insert tips is crucial.

Biofilm disruption and removal is also aided by cavitation at the tip of the insert, and the shape of the ultrasonic tip together with loading influences cavitation. Longer probes offer more cavitation toward the tip.[3] An example would be the long, thin scaler insert tips designed specifically for biofilm disruption.



Figure 1. Thin, probe-like piezoelectric scaler insert tips

Preserving dentin

Slimmer probe-like tips have been found to remove less root dentin than wider tips, as do lower applied forces.[4] Heavy lateral force and a 45° angulation are most detrimental when using piezoelectric ultrasonic scaler inserts at all power settings, and this should be avoided. Scaler tips should be used without being angulated, at or close to 0°.[5] At a medium power setting, greater risk of root surface damage has been observed with manual instrumentation than with ultrasonic scaling.[1] Root surfaces also have been found to be smoother after use of (unworn) ultrasonic tips than after manual instrumentation in some studies.[6,7] However, worn tips result in significantly greater root surface roughness than new tips, especially when used at a 45° angle.[8]

Ultrasonic Frequencies and Power Settings

Increasing vibration at insert tips increases cavitation,[3] and increasing power settings in general increases the amount of vibrational movement of the scaler tip (the 'tip amplitude' or 'vibration displacement amplitude'); differences have, however, been observed between different tips of similar designs.[9] A system whereby the correct ultrasonic frequency is automatically selected simplifies and speeds up treatment, also making it more comfortable for patients. Pure Newtron devices (Satelec) feature a Cruise Control System that automatically controls tip vibration and ensures that the tip is operating at the selected ultrasonic frequency – the tip amplitude is continuously monitored and the power delivered to the tip adjusted, based on the resistance encountered. This continuous and automatic power adjustment results in fast, smooth, and efficient treatment. A color-coding system is also used for Newtron tips, indicating the appropriate power setting for a given tip and for a given indication; this reduces complexity for the clinician and the risk of tip breakage or iatrogenic damage to the root surface.

TABLE 1. Factors in dentin preservation
Use of slimmer and probe-like tips
Lower applied forces
Tips used at (or close to) zero angulation to the root surface
Appropriate power setting for a given procedure
Replace worn tips, do not use

Irrigation and Cooling

Ultrasonic devices may either connect to the dental unit waterlines for coolant and irrigation, or to a dedicated irrigation system. For those with connection to the waterline, a connection that is quickly and easily made saves time and is potentially more ergonomic. Scaling and root planing using a device with a dedicated water supply provides the option of using sterile water or saline, or if preferred permits irrigation with an antimicrobial agent. Some devices, including the Pure Newtron P5XS, feature an independent irrigation chamber/tank. This makes the device more easily portable, able to be used in remote field locations, and no longer dependent on a reliable, safe water supply.

Patient Comfort

Less tissue distension occurs with ultrasonic scaler inserts than with manual scalers as calculus can be removed using a coronal approach rather than first having to insert a manual scaler under the calculus. These differences result in improved patient comfort when ultrasonic scalers are used. In addition, slimmer insert tips reduce the amount of tissue distension, also contributing to patient comfort. In comparing patient comfort, significantly reduced postprocedural sensitivity has been observed in studies comparing ultrasonic scaling and manual scaling with curettes.[10] Lastly, reduced chairside time helps to lessen patient fatigue and improve patient comfort.

Ergonomics

From an ergonomics perspective, reduced musculoskeletal stress and fatigue results in fewer occupational injuries among clinicians. First and foremost, the clinician must work in an ergonomic position and have the patient change position during treatment as needed. The risk of muscu-

loskeletal injury during scaling and root planing procedures is relatively high due to the repetitive nature of these procedures, especially with manual instrumentation. There is less risk of occupational injury with ultrasonic therapy than manual scaling, as manual instrumentation necessitates awkward grips and the simultaneous manual application of force.[11]

Using a lightweight ultrasonic handpiece and inserts reduces fatigue. Together with use of a variety of insert tip designs that can be applied in different sites without awkward wrist or digit positioning, this helps with ergonomics. Silicone grips also improve ergonomics.

The Pure Newtron ultrasonic devices have slim, lightweight handpieces designed to improve clinician comfort and the Newtron P5XS ultrasonic device also has an LED light for illumination of the clinical site. It can be mounted at the front of the device or on the side, giving the operator choice. The handpiece holder is less likely to fall—and also less likely to result in a sharps injury—if mounted on the side such that the operator is not reaching over the end of the insert tip with it pointing upwards and backwards in a console. The device is also on an incline, improving visibility and ergonomics with superior access to the device's settings.

Reduced fatigue plus improved visibility is safer for the clinician, reduces chairside time and thereby also reduces the potential for occupational injury and improves patient comfort. Other features of ultrasonic devices that help improve ergonomics include swivel connectors, LED lighting, automated adjustments, foot pedals, and large dials that are easy to grip.

Table 2. Factors in ergonomics during ultrasonic instrumentation

Lightweight ultrasonic handpiece
Silicone grips
Wide variety of inserts
Access to sites without awkward wrist and digit positioning
No requirement for awkward pinch forces
Faster procedures (reduced fatigue and stress)
LED illumination
Large, accessible dials
Swivel connectors
Automated adjustments
Foot pedals
Ability to select placement of handpiece mount on the device
Positioning the patient to improve ergonomic access to clinical sites

Additional Indications for Piezoelectric Ultrasonic Devices

Piezoelectric ultrasonic devices offer additional potential indications, depending on the device and insert tips. Piezoelectric ultrasonic instrumentation is now being used for nonsurgical and surgical endodontics, surgery, and minimally invasive restorative care, in addition to its traditional use for scaling and root planing. These new indications have demonstrated promising results and require the availability of indication-specific ultrasonic insert tips and additive technology.

Surgical piezoelectric ultrasonics requires the use of specific handpieces that are boosted in power and modulate the vibrations, for example the Piezotome 2 from ACTEON which can also be used for nonsurgical periodontal therapy. Piezoelectric ultrasonics has been successfully used surgically for atraumatic extractions before immediate implant placement by first severing the periodontal ligament fibers ultrasonically and then elevating the teeth to complete the extractions.[12] In the same study, the osteotomies were completed using conical ultrasonic insert tips. Piezoelectric ultrasonic surgery also has lead to successful outcomes when a series of ultrasonic insert tips was used for sinus bone grafting procedures, and was found in one study of 53 patients to limit membrane perforation during these procedures.[13] Piezoelectric surgery is reported to cut bone atraumatically in comparison to traditional techniques and to preserve adjacent soft tissue as well as avoiding heat generation.[14]

In endodontics, piezoelectric ultrasonics is playing an increasing role for nonsurgical and surgical

procedures. Passive ultrasonic use with appropriate irrigants has been shown to reduce the level of *Enterococcus faecalis* in root canals through a bactericidal effect.[15] Furthermore, it also has been demonstrated that the effect of ultrasonic irrigation and the irrigant (in this case sodium hypochlorite) is synergistic, resulting in a lower level of colony-forming units of *E. faecalis*,[16] and ultrasonic irrigation is used during endodontic retreatment.[17] Ultrasonics also has made possible conservative removal of pulpal stones that extend toward the apex by using a series of tips,[18] has been found to be useful for the safe identification of root canal openings,[19] to assist with debridement of problematic C-shaped canals,[20] and to result in more rapid apicectomies and higher quality retrograde cavity preparations than use of an ErCr:YSGG laser in *in vitro* testing.[21] Such have been the advances in endodontic therapy that in a recent survey among U.S. endodontists, 45% responded that they used adjunct technology, for example ultrasonics, during endodontic irrigation.[22]

Conservative restorative dentistry also can be achieved using piezoelectric ultrasonics to create Class II preparations with a minimal slot design that preserves hard tissue,[23] and ultrasonic handpieces with diamond-coated burs were found in one study to improve efficiency and to reduce patient discomfort to the extent that patients did not require local anesthetic during removal of old restorations and finalization of preparations.[24]

Versatility

A device that offers multiple indications and a wide selection of insert tips for all of these indications increases its potential usefulness. Therefore, the versatility of a given device and the range of available ultrasonic insert tips are additional considerations when selecting an ultrasonic device. The Newtron series of piezoelectric ultrasonic devices offers more insert tips than other devices, with a total of 70 available for use in the same handpiece for all of these indications. For nonsurgical periodontal therapy alone the range includes curette tips, diamond-coated tips, precision tips, tips for biofilm disruption, and carbon-tipped scaler insert tips for use adjacent to implants.

Infection Control

A final consideration is the ability to ensure infection control. While early ultrasonic devices contained many niches where microorganisms could accumulate, more recent devices are designed to improve infection control. The flat, smooth glass surfaces on the Pure Newtron P5XS and its watertight device reduce potential contamination and also enable disinfection of the devices. The power dial is also easily removed for surface disinfection, while the nose cone is designed to be detached and autoclaved in addition to the ultrasonic insert tips. The handpiece holder can be surface disinfected; or, it can be detached and autoclaved. The handpiece and all accessories including insert tips, wrenches, and storage kits of the Newtron series all meet the ISO Standard for autoclaving.

Table 3. Uses of piezoelectric ultrasonics

Periodontal and Surgery	**Endodontic**
Scaling and root planing; perio surgery	Identification of root canals
Atraumatic extractions	During debridement of C-shaped canals
Use during osteotomies	During irrigation
Use during sinus bone grafting	Removal of pulpal stones
Restorative	Removal of fractured instruments
Minimally invasive restorative preparations	Apicectomy retrograde preparations

Conclusions

Piezoelectric ultrasonic devices are used clinically for numerous indications, in addition to scaling and root planing. Advantages of ultrasonic scaling compared to manual instrumentation include treatment efficacy and efficiency, safer treatment with less potential damage to root surfaces when used properly, improved ergonomics, and patient comfort. Considerations when selecting a piezoelectric ultrasonic scaler include the indications for which it can be used, the range of inserts available, ergonomic and safety features, the level of automation, and overall versatility.

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