Position Paper

Sonic and Ultrasonic Scalers in Periodontics*

This paper was prepared by the Research, Science and Therapy Committee of the American Academy of Periodontology. It is intended to review the safety, efficacy, and role of sonic and ultrasonic scalers in mechanical periodontal therapy. The conclusions presented in this paper represent the position of the American Academy of Periodontology. This information is intended for use by the dental profession. *J Periodontol 2000:71;1792-1801.*

Periodontal therapy consists of treatment modalities aimed at arresting infection and maintaining a healthy periodontium. The periodic mechanical removal of subgingival microbial biofilms (bacterial plaque) is essential for controlling inflammatory periodontal diseases because disease-causing bacteria can repopulate pockets within weeks following active therapy.[1] In the past, periodontal debridement (scaling and root planing) was primarily performed with hand instruments since sonic and ultrasonic scalers originally were designed for gross scaling and removal of supragingival calculus and stains.[2] More recently, these power-driven instruments have been modified to have smaller diameter tips and longer working lengths, thereby providing better access to deep probing sites and more efficient subgingival instrumentation.[3] These technological advances prompted investigators to explore new applications of power-driven scalers in periodontal treatment resulting in a substantial body of literature regarding the safety and efficacy of sonic and ultrasonic scalers for mechanical periodontal therapy. The purpose of this position paper is to summarize the literature and address the role of sonic and ultrasonic scalers in periodontics.

MECHANISMS OF ACTION OF SONIC AND ULTRASONIC SCALERS

There are 2 types of power-driven scalers: sonic and ultrasonic. Sonic scalers are air-turbine units that operate at low frequencies ranging between 3,000 and 8,000 cycles per second (Cps), with a vibratory-type tip movement that is primarily linear or elliptical in direction. Tip movement and the effect on root surfaces can vary significantly depending on the shape of the tip and type of sonic scaler.[4,5] Ultrasonics are currently available in 2 basic types, magnetostrictive and piezoelectric, which differ in their mechanisms of action. Magnetostrictive instruments operate between 18,000 and 45,000 Cps, using flat metal strips in a stack or a metal rod attached to a scaling tip. When an electrical current is supplied to a wire coil in the handpiece, a magnetic field is created around the stack or rod transducer causing it to constrict. An alternating current then produces an alternating magnetic field that causes the tip to vibrate. The tip movement of magnetostrictive units ranges from nearly linear, to elliptical or circular, depending on the type of unit, and shape and length of the tip. Magnetostrictive tip movement allows for activation of all surfaces of the tip simultaneously, providing the option to use the side, back, or front of the tip for adaptation to the tooth surface. A piezoelectric unit operates in the 25,000 to 50,000 Cps range and is activated by dimensional changes in crystals housed within the handpiece as electricity is passed over the surface of the crystals. The resultant vibration produces tip movement that is primarily linear in direction, and generally allows only 2 sides of the tip to be active at any time.

EFFECTS OF MECHANICAL THERAPY: POWER-DRIVEN VERSUS MANUAL SCALERS

Changes in Clinical Outcomes

Differences in root surface alterations have been attributed to linear (piezoelectric) versus elliptical (magnetostrictive or sonic) tip movement.[5,6] However, it is unclear to what extent tip movement or frequency influences the clinical efficacy of powered instruments compared with manual scalers. It is also unclear whether root alterations are different among scaling instruments. Studies comparing sonic, piezoelectric, and magnetostrictive scalers show nearly equivalent clinical results despite a wide variation

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in the relative frequencies of the units (2,000 to 46,000 Cps) and differences in the directional movement of the tips.[7-14] When either powered or hand instrumentation is used for periodontal scaling and root planing, similar reductions in probing depths and bleeding upon probing are achieved (Table 1). Mean probing depth changes ranged from 1.2 mm to 2.7 mm for sonic and ultrasonic scalers. In the 1996 World Workshop in Periodontics,[16] summaries of 27 studies indicated mean probing depth reductions of 1.29 mm for moderate pockets and 2.16 mm for deep pockets following scaling and root planing with hand instruments. This is similar to the probing depth reductions reported in Table 1 for power-driven scalers.[7-14] There have been few studies investigating the effect of power-driven scalers on the subgingival microflora and root-associated toxin. However, these studies appear to demonstrate

Table 1.

Clinical Response to Debridement With Hand Instruments and Ultrasonic and Sonic Scalers*†

Reference	Instruments	Reduction in Sites With Plaque	Probing Depths (mm)		Reduction in % Sites with Bleeding on Probing	Attachment Gain (mm)	Minutes Scaled Per Tooth	Study Length (Months)
			PreTreatment	Post-Treatment Reduction				
Torfarson et al.[7] n = 18 1979	Hand Ultrasonic	17% 5% increase	5.0 5.0	1.70 1.70	45% 45%		3.8 3.0	2
Badersten et al.[8] n = 16 1981	Hand Ultrasonic (Non-molars)		4.2	1.30	82-90%‡			13
Badersten et al.[9] n = 16 1985	Hand Ultrasonic (Non-molars)		5.5 5.5	1.90 1.90	80-83%‡		10.7 10.7	12
Boretti et al.[10] n = 19 1995	Hand Ultrasonic	28%§ 19%§	5.6 5.6	1.83 1.82	91% 92%	1.53 1.14	8.5‖ 4.3‖	1
Laurell et al.[11] n = 12 1988	Hand Sonic	75%‡ 77%‡		72%‡ 67%‡	80% 86%		12¶ 8¶	4
Laurell[12] n = 16 1990	Sonic Sonic scaler	72% 69%		80%‡ 80%‡	95% 97%			8
Loos et al.[13] n = 12 1987	Sonic or Ultrasonic	65%#	≤3.5 4-6.5 ≥7	0.00 1.30 2.70	44%#			12
Loos et al.[14] n = 12 1989	Sonic or Ultrasonic	None	≤3.5 4-6.5 ≥7	–0.50 1.20 2.30	35%#	Single 0.6** Flat 1.0 Furca 1.3	6.7 molars 3.7 others	24

* Adapted from Drisko and Lewis, 1996.[15]
† No significant differences between treatments.
‡ Percent reduction in number of sites with ≥4 mm probing depths.
§ No home care given.
‖ Estimated minutes per tooth, data reported as 60 minutes. per quadrant for hand and 30 minutes per quadrant for ultrasonic.
¶ Performed by dental hygiene students.
\# Mean estimated from a graph.
** Single rooted, molar flat surfaces and furcations.

that power-driven scalers decrease subgingival microflora similarly to hand scalers.[16] The disruption and reduction of the subgingival microbiota are important aspects of successful mechanical periodontal therapy.

Since attitudes toward specific mechanical therapy techniques may influence patient compliance with prescribed treatment regimens, patient acceptance of power-driven scalers versus hand instruments is important. Surprisingly, with regard to patient comfort, very little data exist comparing different types of instrumentation.[17-20] Tip movement, type of lavage, tip size, and manual versus auto-tuning have been investigated for power-driven scalers, but the influence of these factors on patient comfort or compliance is inconclusive.

When power-driven scalers are compared to manual scalers, most in vivo studies show no statistical differences in probing depth reduction or bleeding on probing.[7-14,16] It can be concluded that improvements in clinical parameters are nearly equal for all mechanical instrumentation techniques as long as sufficient time is spent to thoroughly debride the roots. Therefore, when reduction of probing depths, bleeding upon probing, and complete calculus removal are desired therapeutic endpoints, use of manual or power-driven scalers or their combined use is appropriate for the mechanical debridement of periodontal pockets. Most clinical studies that compared sonics and ultrasonics to manual scalers have not evaluated attachment level changes. Nevertheless preliminary evidence suggests that attachment levels are most likely improved following sonic and ultrasonic debridement at a magnitude similar to hand scaling.[8-10]

Plaque Removal

Effective subgingival plaque control is necessary for optimal wound healing and maintenance of healthy gingival tissues. Removal of subgingival plaque is important since recolonization may occur within months despite good supragingival plaque control, and within weeks after poor plaque control.[1] Recolonization of bacteria establishes the on-going need for mechanical plaque removal by both the patient and the dentist or dental hygienist.[21-26] Studies have confirmed that plaque removal can be equivalently accomplished by power-driven or hand instruments.[7,10-12,16,27,28]

However, there may be additional effects in using power-driven scalers in conjunction with hand scalers for removing bacterial plaque. Specifically, the lavage effect produced by the water coolant used with power-driven scalers provides a constant flushing activity during instrumentation that appears to have some therapeutic effects.[29-32] Features unique to ultrasonic scalers not found with manual scalers include cavitation and microstreaming which are physiologic properties associated with the operation of the ultrasonic generators themselves.[29,31,32] In ultrasonic units, the water spray necessary to cool the tip undergoes a transformation producing cavitational activity within the water that is capable of disrupting bacterial cell walls.[32] These actions may also dislodge plaque and other surface irritants at and slightly beyond the reach of the instrument tip. In general, the evidence suggests that the disruption and removal of subgingival biofilms (plaque) can be accomplished with power-driven scalers at a level comparable to manual scalers.[33-36]

Calculus Removal

Calculus is a rough, porous, and plaque-retentive substance that adheres to the root surface. Comparisons between studies of manual and power-driven scalers for calculus removal are difficult, since there is no consistency between study designs or methodologies. This shortfall has led to conflicting evidence with regard to the superiority of hand versus sonic or ultrasonic instruments for calculus removal.[37-45]

A goal of periodontal instrumentation is to effectively remove plaque and calculus, while causing the least amount of root surface damage. Attempts to completely remove calculus deposits require extensive instrumentation and can result in significant amounts of cementum and dentin loss, thereby inducing dentinal hypersensitivity and increased prevalence of pulpitis.[46,47] There are some data to suggest that one way to avoid creating extensive iatrogenic root surface damage during periodontal debridement is to perform the minimal number of multiple light overlapping strokes with an ultrasonic scaler that are necessary to achieve a clean root.[48] Using the ultrasonic scaler on medium or low power or using the tip of the sonic scaler at an angle close to zero degrees to the tooth surface may enable the clinician to perform a thorough debridement without excessive damage to root surfaces.[49]

Endotoxin and Cementum Removal

Until recently, endotoxin was thought to be embedded in, or firmly bound, to cementum. Thus it was believed that extensive cementum removal by scaling and "planing" the root surface was required to remove endotoxins.[50] An earlier report[51] suggested

that hand instruments were more efficient at removing endotoxin than ultrasonics. However, within the last 2 decades, other studies found ultrasonics to be as effective as hand instruments.[48,52,53-60] Currently, it is understood that endotoxin (lipopolysaccharide) is a surface substance which is superficially associated with the cementum and calculus and that it is easily removed by washing, brushing, lightly scaling, or polishing the contaminated root surface.[48,52,61-68]

In conclusion, it appears that periodontal healing can be achieved without extensive cementum removal by either power-driven or manual scalers. In this regard, the consensus report from the 1996 World Workshop in Periodontics states that intentional cementum removal should not be included in current periodontal debridement techniques for the purpose of removing toxic substances from the root surface.[16]

Access to Furcations

Studies on instrumentation of furcations indicate that hand instruments alone are not always adequate to remove root accretions, with or without flap access. These studies confirm the need for different instrumentation approaches.[14,34,69-74] Scaling and root planing are equally as effective in Class I furcations with hand or power-driven instruments, whereas ultrasonics are clearly superior in the treatment of Class II and Class III furcations when used by experienced dental professionals.[34] Others found that ultrasonics are equally successful in debriding facial Class II furcation openings, with or without surgical access.[75] Curets are usually wider than the average furcation opening which is often less than 1 mm.[76] To facilitate furcation instrumentation, many of the new ultrasonic and sonic tips are 0.55 mm or less in diameter. Based on these observations and published studies,[14,34,69-76] sonics and ultrasonics may be the instruments of choice for scaling and root planing furcations.

Pocket Penetration

Adequate access for debridement is more difficult as probing depths increase.[77-82] In this respect, it was reported that complete removal of subgingival plaque and calculus is unlikely to be successful when pockets exceed 3 mm using hand instruments. Others confirmed the inability to completely remove plaque and calculus in pocket depths exceeding 3.73 mm with hand curets, hoes, and files.[80]

One study indicated that non-surgical access to the base of the pocket for calculus removal was superior for power-driven instruments when compared with hand instruments.[81] This clinical trial showed that complete penetration of moderate to deep pockets (5.7 to 8.3 mm) was not achieved by any instruments tested. Hand instruments were least effective in gaining access to the base of the pocket than either the standard or thinner-type ultrasonic tips.[81] These results are supported by studies that suggest sonic and ultrasonic scalers provide better access to the base of the pocket for the removal of plaque and calculus than hand instruments.[80-82]

Root Surface Alterations

Studies evaluating differences with regard to the magnitude of root surface alterations produced by hand, sonic, and ultrasonic instruments are inconclusive.[37,39,40,83-85] When sonics are compared to ultrasonics, some studies find sonics to be equivalent[40] or inferior to ultrasonics with regard to root surface smoothness.[41,85] Several older studies report that curets leave the root surface smoother than ultrasonics.[83-88]

Current evidence suggests that ultrasonics used on medium power may do less damage to the root surface than hand or sonic scalers.[5,81] It is known that surface alterations are directly related to the amount of instrument pressure that is applied.[89,90] In this regard, the evidence shows that ultrasonic and sonic scalers are effective in plaque and calculus removal; however, surface alterations including scratches, gouges, and nicks increase exponentially as the ultrasonic power is increased from medium to high.[40,91] Studies also reveal that as instrument contact time, tip to tooth angle, and instrument pressure is increased, the likelihood of root surface damage is also increased.[49] In addition, the angulation and design of the instrument tip, sharpness of the working edge, the length of time the instrument is in contact with the root, and the cumulative number of strokes have an impact on the degree of root damage.[54,69,89,90] Therefore, when considering all these variables, it is not possible to reach a conclusion regarding the method of instrumentation that causes the least amount of root surface alteration.

Wound Healing

The significance of surface roughness is still unclear since most human studies have not found clinically significant differences in wound healing following hand, sonic or ultrasonic instrumentation.[7,11,12,14,86,92-97]

OTHER CONSIDERATIONS

Restoration Integrity

In addition to root surfaces, restorative materials adjacent to areas instrumented with power-driven scalers

may sustain chips, scratches, or loss of material. For example, porcelain and composite restorations can be significantly damaged by ultrasonic or sonic instrumentation.[98-102] The effect on amalgam surfaces is less clear, since some studies report significant changes in the surface integrity of the restoration while others observed little or no change.[101,103] Sonics and ultrasonics can be useful for the removal of amalgam overhangs.[104,105]

Scaling and Root Planing Plus Sonic or Ultrasonic Debridement

The data indicate that, in general, equivalent clinical outcomes can be obtained and maintained with manual, sonic, or ultrasonic debridement (Table 1). From a different perspective, there are limited data to show that smoother root surfaces are achieved when combining manual plus sonic[106] or manual plus ultrasonic instrumentation[83] during periodontal debridement compared to manual or power-driven scalers alone.

Efficiency

Scaling and root planing require a significant amount of time, regardless of operator proficiency in using power-driven or manual scalers. There are indications that power-driven scalers may increase operator efficiency compared to hand scaling.[10,11,81,107] Several studies have shown that debridement time spent per tooth may be reduced when ultrasonics or sonics are compared to manual scaling.[10,11,107] Some investigators have concluded that the demands on the operator appear to be less with power-driven scalers since sonics and ultrasonics are used with a light touch.[81] Others have stated that the learning curve may be shorter and that less skill may be required to become competent with power-driven scalers than with manual scaling techniques.[15,16,81,107]

Aerosols

The generation of pathogenic bacterial aerosols are a concern for patients, staff, and practitioners.[108-110] One study indicated there is little difference between aerosols produced by sonic or ultrasonic scalers.[111] Other reports indicate that high-speed evacuation devices may be used during sonic and ultrasonic instrumentation to help control splatter of infectious material.[112-113] A recent in vitro study showed that a high volume evacuator attachment to an ultrasonic handpiece significantly reduced the detectable aerosol splatter produced during ultrasonic scaling by 93%.[112] Capturing as much aerosol as possible is very important because preliminary data from one study showed blood in all aerosols produced by an ultrasonic, even when blood was not visible to the naked eye.[113]

Use of antimicrobial mouthrinses prior to sonic and ultrasonic debridement can help control infectious agents in aerosols.[114-116] Studies have shown that a 30-second rinse with an essential oil mouthrinse before instrumentation reduces bacterial counts in the aerosol by about 92.1%, and salivary bacterial level by approximately 50% for up to 40 minutes.[117] Another study indicated that 97% reduction of salivary bacteria was achieved for up to 60 minutes during scaling and root planing following two 30-second rinses with 0.12% chlorhexidine.[117] It can be concluded that good infection control is appropriate at all times, not just during the use of power-driven scalers[118] because aerosols can be suspended in the air for up to 30 minutes.

Effect on Cardiac Pacemakers

In general, modern pacemakers are shielded against electromagnetic interference, with the exception of sources in the medical field including electrocautery and defibrillation, magnetic resonance imaging (MRI), lithotripsy, transcutaneous nerve stimulation, and other magnetostrictive ultrasonic scalers and ultrasonic bath cleaners used in dentistry.[119-121] No reports of interference by piezoelectric scalers have been noted.[119,121] In view of the concern with possible effects of magnetic fields on pacemakers, exposure to magnetostrictive ultrasonic scalers should be avoided due to the potential deleterious effects ultrasonic instruments may produce in patients with cardiac pacemakers.[119]

Ultrasonic Antimicrobal Lavage

Less well-documented are the clinical advantages of using antimicrobial lavage in power-driven scalers instead of water. Some short-term studies have not supported the use of 0.02% or 0.12% chlorhexidine with ultrasonics, because the results did not reach statistical significance in probing depths and bleeding on probing.[18,122] However, another study using a combination of ultrasonic scaling and root planing with 0.12% chlorhexidine resulted in statistically but not marked (0.5 mm) short-term reductions in probing depths.[123]

There is, however, renewed interest in more specific targeted therapies using ultrasonic lavage in immunocompromised patients and those with advanced recurrent or refractory periodontitis. One group treated a population of poorly controlled, non-

insulin-dependent (Type 2) diabetics[124] and reported significant clinical improvements compared to baseline groups when chlorhexidine, povidone iodine, or water was used as an antimicrobial lavage in an ultrasonic along with ultrasonic curettage and systemic antibiotics. However, it was also noted that the addition of the mentioned antimicrobial did not attain a better result than the use of water along with the ultrasonic. In several small clinical trials, thorough debridement along with topical application of povidone iodine enhanced the effect of non-surgical periodontal therapy.[126-127] However, due to the small sample sizes, these data are inconclusive and require confirmation in larger controlled clinical trials.

FUTURE RESEARCH

New techniques are being explored to improve access and visualization for scaling and root planing. For instance, one group described using a combination of papillae reflection, sonic scalers, and fiber optics.[128] Other ultrasonic instrument designs that may increase efficiency in accessing and debriding difficult to reach anatomical areas of the root surface are being developed and tested, such as the ball-tipped inserts for furcations.[72] In addition, other devices[129] and instrumentation techniques appropriate for the maintenance of osseointegrated implants are being studied.

SUMMARY

Ultrasonic and sonic scalers appear to attain similar results as hand instruments for removing plaque, calculus, and endotoxin. Ultrasonic scalers used at medium power seem to produce less root surface damage than hand or sonic scalers. Due to instrument width, furcations may be more accessible using ultrasonic or sonic scalers than manual scalers.

It is not clear whether root surface roughness is more or less pronounced following power-driven scalers or manual scalers. It is also unclear if root surface roughness affects long-term wound healing. Periodontal scaling and root planing includes thorough calculus removal, but complete cementum removal should not be a goal of periodontal therapy. Studies have established that endotoxin is weakly adsorbed to the root surface, and can be easily removed with light, overlapping strokes with an ultrasonic scaler.

A significant disadvantage of power-driven scalers is the production of contaminated aerosols. Because ultrasonics and sonics produce aerosols, additional care is required to achieve and maintain good infection control when incorporating these instrumentation techniques into dental practice.

Preliminary evidence suggests that the addition of certain antimicrobials to the lavage during ultrasonic instrumentation may be of minimal clinical benefit. However, more randomized controlled clinical trials need to be conducted over longer periods of time to better understand the long-term benefits of ultrasonic and sonic debridement.

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