J Periodont Res 2007; 42; 90–95

JOURNAL OF PERIODONTAL RESEARCH

A comparison of root surface instrumentation using two piezoelectric ultrasonic scalers and a hand scaler *in vivo*

H. Kawashima[1], S. Sato[2], M. Kishida[3], K. Ito[4]

[1]Department of Periodontology, Nihon University School of Dentistry, [2]Department of Periodontology, Division of Advanced Dental Treatment, Dental Research Center, Nihon University School of Dentistry, [3]Department of Periodontology, Nihon University School of Dentistry, and [4]Department of Periodontology, Division of Advanced Dental Treatment, Dental Research Center, Nihon University School of Dentistry, Tokyo, Japan

Kawashima H, Sato S, Kishida M, Ito K. A comparison of root surface instrumentation using two piezoelectric ultrasonic scalers and a hand scaler in vivo. *J Periodont Res 2007; 42: 90–95. © 2006 The Authors. Journal compilation © 2006 Blackwell Munksgaard Ltd*

Background and Objective: This study compared the effectiveness of two piezoelectric ultrasonic scalers and a hand scaler for subgingival scaling and root planing *in vivo*.

Material and Methods: Fifteen patients with advanced periodontal disease and with teeth scheduled for extraction were selected for this study. Three experimental groups of 10 teeth each were treated with one of two piezoelectric ultrasonic scalers [Vector™ scaler and Enac® scaler] or with a hand scaler. Instrumentation was continued until the root surface felt hard and smooth to an explorer tip. The root surface characteristics after instrumentation were examined using scanning electron microscopy, and the amount of remaining calculus, roughness and loss of tooth substance were estimated using the remaining calculus index and roughness loss of tooth substance index.

Results: The remaining calculus index did not differ significantly among the three groups. The roughness loss of tooth substance index was significantly lower for the Vector™ scaler and Enac® scaler groups than for the hand scaler group and also differed significantly between the Vector™ scaler and Enac® scaler groups.

Conclusion: This study suggests that the Vector™ scaler produces a smooth root surface with minimal loss of tooth substance. It is a reasonable choice for gentle periodontal maintenance treatment.

Shuichi Sato, Department of Periodontology, Nihon University School of Dentistry, 1-8-13, Kanda Surugadai, Chiyoda-ku, Tokyo 101-8310, Japan
Tel: +81 3 32198107
Fax: +81 3 32198349
e-mail: sato-su@dent.nihon-u.ac.jp

Key words: periodontal maintenance; root cementum; scaling and root planing

Accepted for publication June 13, 2006

Instruments used to prepare root surfaces mechanically should not excessively damage, gouge, trough, or remove injudicious amounts of root structure. The smoothest root possible should be one goal of successful root planing (1). Although residual root roughness *in vivo* has a minimal effect on healing of the periodontal apparatus (2), it may facilitate further bacterial accumulation and subsequent calculus deposition. Therefore, the ideal instrument should enable the removal of all extraneous substances from the root surfaces without any iatrogenic effects. Recent studies have shown that endotoxins are located on the root surface, rather than within it, in periodontal disease (3). This being the case, the commonly accepted idea concerning scaling and root planing is that excessive removal of cementum in order to remove endotoxins is unnecessary.

Sonic and ultrasonic scalers have been modified to have smaller tips and longer working lengths, thereby providing better access to deep probing sites and more efficient subgingival instrumentation (4–6). However, their disadvantages include damage to the root surfaces, danger to the practitioner from aerosol bacteria, and possible

overheating during subgingival treatment.

Recently, a Vector™ scaler (Dürr Dental, Bietigheim-Bissingen, Germany) was developed for use in scaling and root planing, and has been used to remove biofilms and subgingival calculus in a gentle manner (7). Kishida *et al.* (8) compared the effects of the Vector™ scaler, a conventional ultrasonic scaler, and a hand scaler *in vitro*. They showed that the Vector™ scaler allowed scaling and root planing with minimal damage to the root surface and with tight attachment of fibroblasts.

This study assessed the extent to which an ultrasonic scaler removed calculus and tooth substance *in vivo* compared with a conventional ultrasonic scaler and a hand scaler.

Material and methods

Fifteen patients with advanced periodontal disease and with teeth scheduled for extraction were selected for this study. The patients had no antibiotic therapy for 6 mo before or during this study and no systemic disease. They had not received any periodontal treatment for 2–3 yr. All patients who participated were required to sign an informed consent statement approved by the Nihon University Committee on the Protection of Human Subjects. The selection criteria included a single-rooted tooth (11 incisors and 19 premolars) with a pocket depth of 7–10 mm, mobility greater than or equal to Miller's class II, and radiographical bone loss for more than two-thirds of the root length. All the selected pockets bled on probing and had calculus deposits that could be detected both clinically and on radiographs. The teeth had no caries on the mesial or distal surfaces. Three experimental groups of 10 teeth each were treated with different methods (Fig. 1): the Vector™ scaler, tuned to the usual setting with polishing fluid containing hydroxyapatite and a metal probe tip insert at 25 kHz; an Enac® type 5 scaler (Osada, Tokyo, Japan); or a Gracey-curette hand scaler (HS; Hu-Friedy, Chicago, IL, USA). Root surface instrumentation using a closed approach was carried out on the proximal surface. The instrumentation was continued until the root surface felt hard and smooth to an explorer tip. Immediately before the teeth were extracted, a reference groove was placed on each tooth, with a no. 2 diamond bur, at the level of the gingival margin. The root surfaces were instrumented by two investigators, well trained in periodontal treatment, until smooth, as evaluated by another investigator who was blind to the technique being used. Before using the instrumentation, the investigators had been trained to remove calculus from extracted teeth and to adopt a stable lateral force using the method of Kishida *et al.* (8).

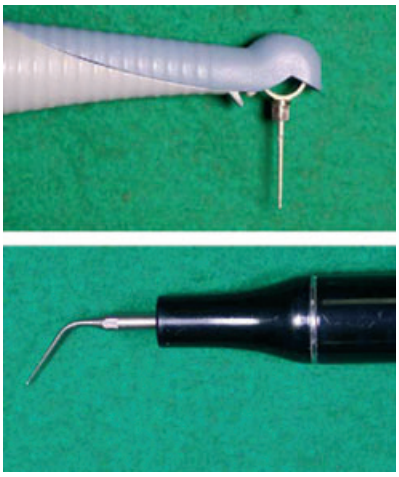

Fig. 1. The two piezoelectric ultrasonic scalers: the Vector™ scaler and the Enac® type 5 scaler.

After extraction, the teeth were irrigated with saline, stored in 2.5% glutaraldehyde, dehydrated in an ascending ethanol series, processed with a Critical Point Dryer (HCP-2; Hitachi, Tokyo, Japan) and gold-coated with an Ion Coater (JFC-1100; Jeol, Tokyo, Japan). On each root, an area measuring 5 mm in height and $\approx$10 mm in width was selected from the cemento–enamel junction. The following landmarks delimited the treated proximal surfaces: the apical edge of the bur groove, the proximal line angles and the coronal border of the remaining connective tissue fibers. The root surface characteristics after instrumentation were examined using scanning electron microscopy (JSM-T100; Jeol). Scanning electron micrographs, magnified 100- or 500-fold, were selected randomly. The amount of remaining calculus, roughness and loss of tooth substance were estimated using the remaining calculus index and roughness loss of tooth substance index (9) (Tables 1 and 2). Statistical analysis was based on a one-way factorial analysis of variance (ANOVA) with the Bonferroni test. A risk rate of less than 5% was evaluated as being significantly different.

After surface observation, the specimens were cut perpendicular to the long axis for cross-sectional observation. We used the untreated proximal surface as a control. The cross-sections were examined using the modified

Table 1. Remaining calculus index

0	No calculus remaining on the root surface
1	Small patches of extraneous material probably consisted of calculus
2	Define patches of calculus confined to small areas
3	Considerable amounts of remaining calculus appearing as one or a few voluminous patches scattered on the treated surface

Table 2. Roughness and loss of tooth substance index

0	Smooth and even root surface without marks from the instrumentation and with no loss of tooth substance
1	Slightly roughened or corrugated local areas confined to the cementum
2	Definitely corrugated local areas where the cementum may be completely removed, although most of the cementum is still present
3	Considerable loss of tooth substance with instrumentation marks into the dentin. The cementum is completely removed in large areas, or it has a considerable number of lesions from the instrumentation

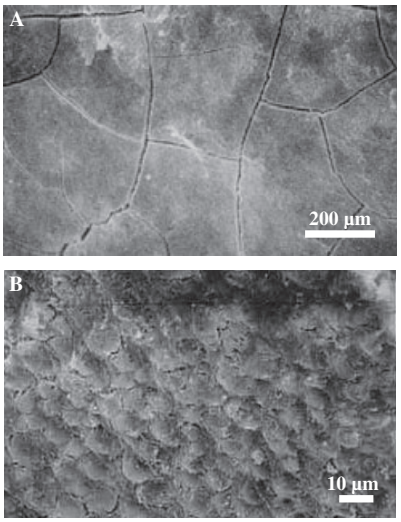

Fig. 2. Scanning electron photomicrographs of the Vector™ scaler-treated root surface (original magnifications ×100, ×1000). (A) Roots treated with the Vector™ scaler had a clean, smooth surface. (B) The dome-shaped cementum structure is observed in many regions.

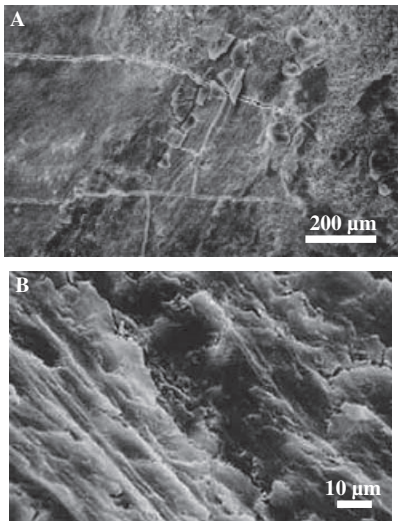

Fig. 3. Scanning electron photomicrographs of the Enac® scaler-treated root surface (original magnifications ×100, ×1000). (A) The roots treated with the Enac® scaler sometimes revealed grooves running parallel to the long axis of the roots and cavitation of cementum. (B) Irregularities and defects were observed in some areas.

parameters of Rupf *et al.* (10): presence or absence of calculus, amount of residual cementum measured in micrometers, surface topographical analysis (shallow, medium, or deep grooves, i.e. < 10, 10–20, or > 20 μm, respectively), and smoothness of the root surface determined by touch (rough or smooth). For each sample, 10 randomly selected locations were analyzed.

Results

The roots treated with the Vector™ scaler had a clean, smooth surface under low magnification (Fig. 2A). Under higher magnification, the dome-shaped cementum structure was observed in many regions, although some calculus remained (Fig. 2B). The roots treated with the Enac® scaler sometimes revealed grooves running parallel to the long axis of the roots and cavitation of the cementum (Fig. 3A). Under higher magnification, irregularities and defects were observed in some areas (Fig. 3B). The roots treated with the hand scaler had many linear injuries, which were thought to have been caused by instrumentation (Fig. 4A). Under higher magnification, the entire root surface was covered with a smear layer (Fig. 4B).

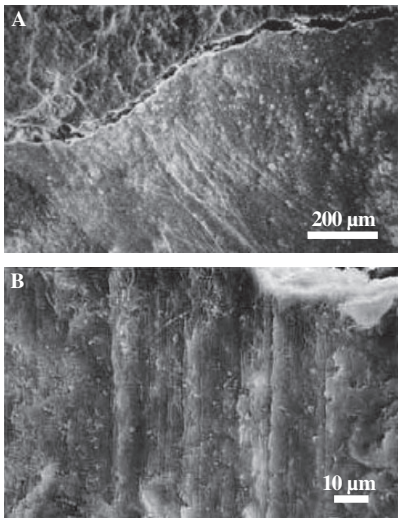

Fig. 4. Scanning electron photomicrographs of the hand scaler-treated root surface (original magnifications ×100, ×1000). (A) The roots treated with the hand scaler had many linear injuries. (B) The entire root surface was covered with a smear layer.

Evaluation of the remaining calculus using the remaining calculus index showed no significant differences among the three groups (Fig. 5).

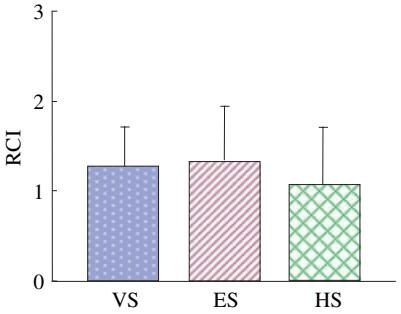

Fig. 5. Remaining calculus index (RCI) for each instrument tested. ES, Enac® scaler; HS, Gracey-curette hand scaler; VS, Vector™ scaler. $n = 30$.

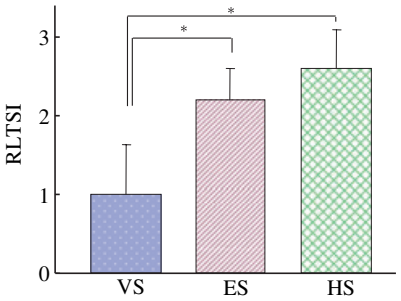

Fig. 6. Roughness and loss of tooth substance index (RLTSI) for each instrument tested. ES, Enac® scaler; HS, Gracey-curette hand scaler; VS, Vector™ scaler. $n = 30$.

Evaluation of the root surface texture using the roughness loss of tooth substance index gave values for the Vector™ scaler and Enac® scaler groups that were significantly lower than that for the hand scaler group, and a significant difference was observed between the Vector™ scaler and Enac® scaler groups (Fig. 6).

In the Vector™ scaler group, the cross-section was smooth, and the remaining cementum was thick (Fig. 7A). There were also areas of thick cementum in the ES group, although some areas had a dimpled surface (Fig. 7B). In the hand scaler group, there were some areas with thin or absent cementum (Fig. 7C). The Vector™ scaler and Enac® scaler groups had significantly more remaining cementum than the hand scaler group (Fig. 8). The microscopic assessments of the surface topography in the Vector™ scaler, Enac® scaler and hand scaler groups are summarized in Table 3.

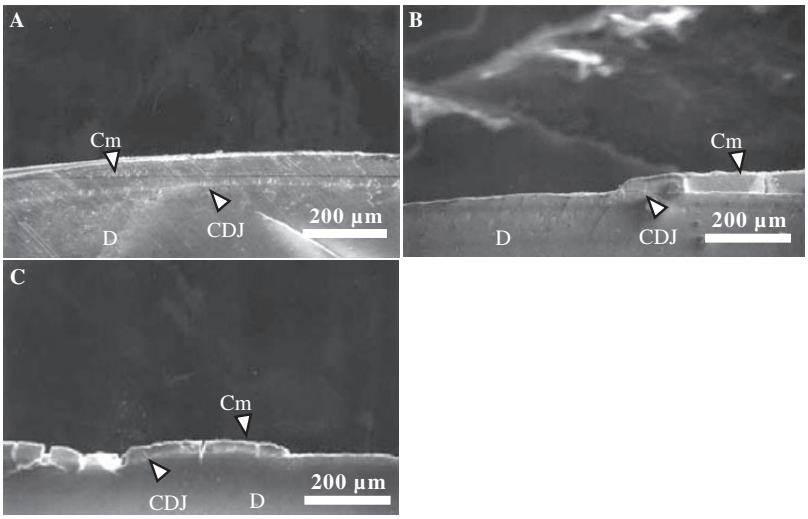

Fig. 7. Scanning electron micrographs of cross-sections of the treated root surfaces (original magnification ×100). (A) The roots treated with the Vector™ scaler were smooth, and a thick cementum layer remained (mean = 45 µm). (B) The roots treated with the Enac® scaler (ES) had a thinner cementum layer (mean = 30.5 µm), with loss of cementum in some areas. (C) The roots treated with the hand scaler (HS) had a thin cementum layer (mean = 8.7 µm), with loss of cementum in some areas. CDJ, cemento dentinal junction; Cm, cementum; D, dentin.

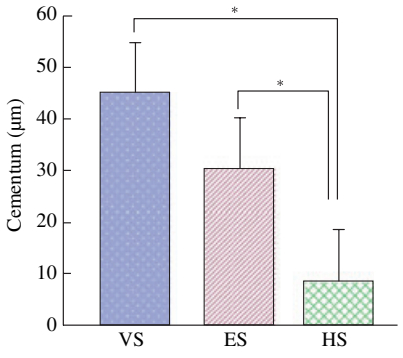

Fig. 8. Mean thickness of the cementum in each group. ES, Enac® scaler; HS, Gracey-curette hand scaler; VS, Vector™ scaler. $n = 30$.

Discussion

This study compared the root surface characteristics following the use of two different piezoelectric ultrasonic scalers and a hand instrument. With the Vector™ scaler, the root surface was clean and smooth, and cementum was observed, although some calculus remained. By contrast, with the Enac® scaler, there were some grooves running parallel to the long axis of the roots and cavitation of the cementum. The roots treated with the hand scaler had many linear injuries, and the entire root surface was covered with a smear layer.

The remaining calculus index values did not differ significantly among the three groups. Rupf *et al.* (10) showed that the Vector™ scaler left more calculus than another ultrasonic scaler and a hand scaler. Braun *et al.* (11) showed that calculus removal with the Vector™ scaler depended significantly on the selection of inserts and irrigation fluids and that a metal probe insert with polishing fluid was less effective than a metal curette. In this study we used a metal probe insert with polishing fluid but did not limit the time allowed for removing calculus. The Vector™ scaler required up to four times longer to remove all the calculus. Kishida *et al.* (8) also found that the Vector™ scaler took a longer time to remove calculus *in vitro*.

Several studies have suggested that hand instruments produce a significantly smoother root surface than ultrasonic scalers (1,12,13), whereas another study suggested that an ultrasonic scaler produced a smoother surface than hand instruments (14). The roughness loss of tooth substance index was significantly lower for the Vector™ scaler group than for the Enac® scaler and hand scaler groups. The Vector™ scaler and Enac® scaler groups had significantly more remaining cementum than the hand scaler group. The cross-sectional observations confirmed these results. Braun *et al.* (8) suggested that the Vector™ scaler with polishing fluid or conventional ultrasonics should be used for root debridement without extensive root substance removal. Furthermore, the lateral forces, power setting and angulation can influence root substance removal (15–17). We did not measure the lateral forces during treatment, although the investigators were trained to remove calculus with little force, using periodontally involved extracted teeth *in vitro*.

The cross-sections in the Vector™ scaler and Enac® scaler groups showed more remaining cementum than those in the hand scaler group, although those in the Enac® scaler group had a somewhat rough surface. An *in vitro* study comparing the volume of bovine root substance loss using sonic, ultrasonic and hand instruments showed that hand instruments removed most of the root substance (18). To minimize the clinical variables, only single rooted teeth were selected in the present study. Furthermore, before extraction, we asked the patients whether they had previously received periodontal treatment. Recently, Ruhling *et al.* (19) compared root substance loss after treatment with three different ultra-

Table 3. Root surface condition after instrumentation

Groups	VS	ES	HS
Residual cementum (µm)	45	30.5	8.7
Surface topography (SEM)	Shallow	Shallow	Deep
Surface smoothness (tactile sense)	Smooth	Smooth	Smooth
Dentin exposure	None	None	Exposed

ES, Enac® scaler; HS, Gracey-curette hand scaler; SEM, scanning electron microscopy; VS, Vector™ scaler.

sonic scalers *in vivo*. They treated the proximal surface and used the other side as a control. We followed their method, although the results were not sufficient to confirm the conditions. In our study, the average thickness of the cementum was 60–110 μm, but no absolute values could be given as the mesial and distal cementum thicknesses were not necessarily equal. The tip movement of an ultrasonic scaler is generated in different ways, resulting in various amplitudes and patterns of movement. These differences may explain the observed variation in root surface structure (5,9,14,20).

Many clinicians consider a smooth, hard root surface to be the desired endpoint of mechanical root planing. However, smooth, hard root surfaces may reflect the excessive removal of hard tissues, which has been reported to cause hypersensitivity or pulpitis (21). Therefore, others have advocated gentle treatment of the root surface, based on observations that endotoxin does not penetrate the exposed root cementum, but forms a loosely attached superficial layer on its surface (3,22–24). The choice of hand or ultrasonic instruments for root debridement is controversial. The hand instrument proved to be more effective at removing cementum, when compared with the ultrasonic device, using scanning electron microscopy (25). In contrast, Chiew *et al*. (23) and Smart *et al*. (22) demonstrated good results with ultrasonic instrumentation in terms of the amount of lipopolysaccharide on the root surface. Checchi & Pellicioni (26) found that ultrasonic instruments were able to remove endotoxins from the root surface, and that there were no differences with respect to fibroblast adhesion after using any of the instruments. In a dog study, Nyman *et al*. (27) reported that the result of healing following flap surgery was similar, regardless of whether the previously exposed root cementum had been removed. They suggested that the elimination of soft bacteria deposits from the root surface, rather than the removal of the cementum, is essential for achieving periodontal health following therapy. Moreover, there is evidence that periodontal repair occurs even in the presence of residual calculus (28). It appears that periodontal healing can be achieved without extensive cementum removal by either the Vector™ scaler or the Enac® scaler. Intentional cementum removal should not be included in current periodontal debridement techniques for the purpose of removing toxic substances from the root surface (29).

Given its limitations, this study showed that the Vector™ scaler preserved a similar amount of cementum as the Enac® scaler, while producing a smooth root surface. Therefore, the Vector™ scaler might be more useful during the maintenance phase. In this study, the number of teeth in each group was small, and further study is needed to determine whether the observed structural differences in the root surface are of clinical significance.

References

1. Bye FL, Ghilzon RS, Cafesse RG. Root surface roughness after the use of different modes of instrumentation. *Int J Periodontics Restorative Dent* 1986;**6:**36–47.
2. Khatiblou FA, Ghodssi A. Root surface smoothness or roughness in periodontal treatment. A clinical study. *J Periodontol* 1983;**54:**365–367.
3. Moore J, Wilson M, Keiser JB. The distribution of bacterial lipopolysaccaride (endotoxin) in relation to periodontally involved root surfaces. *J Clin Periodontol* 1986;**13:**748–751.
4. Dragoo MR. A clinical evaluation of hand and ultrasonic instruments on subgingival debridement. Part 1. With unmodified and modified ultrasonic inserts. *Int J Periodontics Restorative Dent* 1992;**12:** 311–323.
5. Kocher T, Plagmann HC, Gutsche C. Ein neuer Weg zur Furkationsvehandlung. *Dtsch Zahnärztl Z* 1988;**43:**677–680.
6. Kocher T, Ruehling A, Momsen H, Lagmann HC. Effectiveness of subgingival instrumentation with power-driven instruments in the hands of experienced and inexperienced operators. A study on manikins. *J Clin Periodontol* 1997;**24:**498–504.
7. Klinger G, Klinger M, Pertsch J, Guentsch A, Boerner D. Parodontal therapie mit Hilfe des Ultraschallgerätes Vector. *Quintessenz* 2000;**51:**813–820.
8. Kishida M, Sato S, Ito K. Effects of a new ultrasonic scaler on fibroblast attachment to root surfaces: a scanning electron microscopy analysis. *J Periodont Res* 2004;**39:**111–119.
9. Lie T, Leknes KN. Evaluation of the root surfaces of air turbine scalers and ultrasonic instruments. *J Periodontol* 1985;**56:**522–531.
10. Rupf S, Brader I, Vonderlind D *et al*. In vivo, clinical and microbiological evaluation of linear oscillating device for scaling and root planing. *J Periodontol* 2005;**76:**1942–1949.
11. Brau A, Krause F, Frentzen M, Jepsen S. Removal of root substance with Vector™-system compared with conventional debridement *in vitro*. *J Clin Periodontol* 2005;**32:**153–157.
12. Cross-Poline GN, Stach MN, Newman SM. Effects of curette and ultrasonic on root surfaces. *Am J Dent* 1995;**8:**131–133.
13. Meyer K, Lie T. Root surface roughness in response to periodontal instrumentation studied by combined use of microroughness measurements and scanning electron microscopy. *J Clin Periodontol* 1977;**4:**77–91.
14. Jacobson L, Blomlof J, Lindskog S. Root surface texture after different scaling modalities. *Scand J Dent Res* 1994;**102:**156–160.
15. Flemmig TF, Petersilka GJ, Mehl A, Hickel R, Klaiber B. The effect of working parameters on root substance removal using a piezoelectric ultrasonic scaler *in vitro*. *J Clin Periodontol* 1998; **25:**158–163.
16. Flemmig TF, Petersilka GJ, Mehl A, Hickel R, Klaiber B. Working parameters of a magnetostrictive ultrasonic scaler influencing root substance removal *in vitro*. *J Clin Periodontol* 1998;**69:**547–553.
17. Flemmig TF, Petersilka GJ, Mehl A, Hickel R, Klaiber B. Working parameters of a sonic scaler influencing root substance removal *in vitro*. *Clin Oral Invest* 2000;**1:**55–60.
18. Schmidlin PR, Beuchat M, Busslinger A, Lehmann B, Lutz F. Tooth substance loss resulting from mechanical, sonic and ultrasonic root instrumentation assessed by liquid scintillation. *J Clin Periodontol* 2001;**28:**1058–1066.
19. Ruhling A, Bernhardt O, Kocher T. Subgingival debridement with Teflon-coated sonic scaler insert in comparison to conventional instruments and assessment of substance removal on extracted teeth. *Quintessence Int* 2005;**36:**446–452.
20. Jotikasthira NE, Lie T, Leknes KN. Comparative *in vitro* studies of sonic, ultrasonic and reciprocating scaling instruments. *J Clin Periodontol* 1992;**19:**560–569.
21. Fukazawa E, Nishimura K. Superficial cemental curettage: its efficacy in promoting improved cellular attachment on human root surfaces previously damaged

by periodontitis. *J Periodontol* 1994;**65:**168–176.

22. Smart GJ, Wilson M, Davies EH, Kieser JB. The assessment of ultrasonic root surface debridement by determination of residual endotoxin levels. *J Clin Periodontol* 1990;**17:**174–178.
23. Chiew SY, Wilson M, Davies EH, Kieser JB. Assessment of ultrasonic debridement of calculus-associated periodontally involved root surface by the limulus amoebocyte lysate assay. An *in vitro* study. *J Clin Periodontol* 1991;**18:**240–244.
24. Drisko CL, Cochran DL, Blieden T, Bouwswan OJ, Cohen RE, Damoulis P. Research Science and Therapy Committee of the American Academy of Periodontology, Position paper: sonic and ultrasonic scalers in periodontics. *J Periodontol* 2000;**71:**1792–1801.
25. Kepic TJ, O'Leary TJ, Kafrawy AH. Total calculus removal: an attainable objective? *J Periodontol* 1990;**61:**16–20.
26. Checchi L, Pelliccioni GA. Hand versus ultrasonic instrumentation in the removal of endotixins from root surfaces in vitro. *J Periodontol* 1988;**59:**398–402.
27. Nyman S, Sarhed G, Ericsson I, Gottolow J, Karring T. Role of diseased root cementum in healing following treatment of periodontal disease. An experimental study in the dog. *J Periodont Res* 1986;**21:**496–503.
28. Listgarten MA, Ellegaard B. Electron microscopic evidence of a cellular attachment between junctional epithelium and dental calculus. *J Periodont Res* 1973;**8:**143–150.
29. Cobb CM. Non-surgical pocket therapy: mechanical. *Ann Peridontol* 1996;**1:**443–490.