J Clin Periodontol 2004; 31: 1003–1006 doi: 10.1111/j.1600-051X.2004.00601.x

Journal of Clinical Periodontology

Significant influence of scaler tip design on root substance loss resulting from ultrasonic scaling: a laserprofilometric in vitro study

Søren Jepsen[1], Mustafa Ayna[2], Jürgen Hedderich[3] and Jörg Eberhard[2]

[1]Department of Periodontology, Operative and Preventive Dentistry, University of Bonn, Germany; [2]Department of Operative Dentistry and Periodontology; [3]Department of Medical Statistics, University Hospital Schleswig-Holstein, Campus Kiel, Germany

Jepsen S, Ayna M, Hedderich J, Eberhard J: Significant influence of scaler tip design on root substance loss resulting from ultrasonic scaling: a laserprofilometric in vitro study. J Clin Periodontol 2004; 31: 1003–1006. doi: 10.1111/j.1600-051X.2004.00601.x. © Blackwell Munksgaard, 2004.

Abstract

Objectives: Ultrasonic scalers have become increasingly popular for subgingival debridement. The aim of the present study was to investigate the influence of different working tip designs (narrow versus wide) on root substance loss caused by either magnetostrictive or piezoelectric ultrasonic devices.

Methods: In this in vitro study, a magnetostrictive ultrasonic system with either Slimline or TFI-10 inserts and a piezoelectric ultrasonic system with either Perioprobe or Type-A inserts were compared at different application forces. Loss of root dentin was determined by defect width, defect depth and defect volume resulting from standardized instrumentation using laser profilometry.

Results: There were consistent and statistically significant differences between all groups. The mean observed dentin alterations for the magnetostrictive ultrasonic device operating a Slimline insert at a lateral force of 0.3 N were 254.4 μm, 6.3 μm and 22.5 μm^3 and for the TFI-10 tip 759.0 μm, 23.5 μm and 160.2 μm^3 for the parameters defect width, depth and volume, respectively. For the piezoelectric ultrasonic system operating a Perioprobe insert, the corresponding mean values were 352.0 μm/12.1 μm/56.4 μm^3 and for the universal Type-A insert they were 402.4 μm/14.0 μm/133.4 μm^3. With application forces of 0.7 N, root substance removal increased up to twofold.

Conclusion: The present investigation could demonstrate that the aggressiveness of magnetostrictive and piezoelectric ultrasonic devices to root substance was significantly influenced by the scaler tip designs, increasing for wider scaler tips as compared with narrow, probe-shaped inserts.

Key words: damage; periodontal therapy; root; ultrasonic scaling

Accepted for publication 24 February 2004

There is considerable evidence to support scaling and root planing as one of the most effective procedures for the treatment of infectious periodontal diseases. In a search for more efficient and less difficult instrumentation, ultrasonic instruments have been introduced as alternatives for hand instruments in periodontal therapy. Clinical studies have shown that ultrasonic scalers are as effective in removing subgingival plaque and calculus as hand instruments and that the improvement in clinical parameters is similar following either ultrasonic debridement or manual scaling (Badersten et al. 1981, 1984, Breininger et al. 1987, Drisko et al. 2000, Tunkel et al. 2002).

Root surface alterations produced by hand or ultrasonic instruments are of particular concern during supportive periodontal therapy, as numerous debridements are performed over years. The cumulative effect of minor substance removal per instrumentation may lead to severe root damage over time. The analysis of publications regarding the aggressiveness to tooth substance comparing ultrasonic scaling devices and hand instrumentation suggests that ultrasonic devices may lead to less damage to the root surface than hand instruments (Ritz et al. 1991, Dragoo 1992, Jacobson et al. 1994, Rees et al. 1999, Busslinger et al. 2001, Schmidlin et al. 2001).

Studies that evaluated the tooth substance removal by different ultrasonic devices suggested that a magnetostrictive unit was more aggressive than a piezoelectric device regarding root substance removal (Flemmig et al. 1998a, b). On the other hand, Busslinger et al. (2001) reported that a piezoelectric device left a rougher surface after instrumentation than a magnetostrictive device.

To our knowledge, a comparison of root substance loss between different scaler tips attached to either piezoelectric or magnetostrictive ultrasonic devices has not been reported. However, different surface alterations could be expected from different working tip designs since the tip geometry may significantly influence the displacement amplitude (Gankerseer & Walmsley 1987).

The following in vitro study was stimulated by the introduction of several new narrow probe-shaped scaler tip designs and the insufficient information regarding the influence of different working tips on root substance loss caused by either magnetostrictive or piezoelectric ultrasonic instrumentation.

Material and Methods

Processing of teeth

A total of 20 teeth that had been extracted for orthodontic reasons were prepared as follows: the roots were separated from the crown and embedded in resin (Stycast 1266, Grace, Westerlo, Belgium). The root surfaces were ground (Grinding device type GT 250, Jean Wirtz, Düsseldorf, Germany) until plane dentin surfaces of about 1 cm^2 were exposed. These surfaces were subsequently polished (extrafine sandpaper, Jean Wirtz) and the specimens were stored in sodium-chloride solution until further instrumentation and analysis.

Experimental root instrumentation

A magnetostrictive ultrasonic scaling device (Cavi-Med 200, Dentsply, York, USA) with either regular (30K TFI-10) or narrow probe-shaped (Slimline 30K FSI/SLI-10S Straight) inserts, and a piezoelectric ultrasonic scaling device (Piezon Master 400, EMS, Nyon, Switzerland) with either universal (Type-A) or narrow probe-shaped (Perioprobe) inserts were used for experimental root instrumentation (Table 1, Fig. 1). All oscillating instruments were operated at medium power setting.

The 20 root specimens were divided into these four treatment groups. On each specimen, there were two test areas (3 × 5 mm) available for the experimental instrumentation, one for a lateral force of 0.3 N and the other one for a lateral force of 0.7 N. Thus, a total of five test areas were instrumented by a given combination of scaler tip and force.

Standardized root instrumentation was performed by moving the mounted ultrasonic handpiece with a computer-operated stepper motor over the test specimens in a horizontal direction. The resin blocks with the exposed root surfaces were attached to a hinge connected to a spring balance that determined the lateral application force (0.3 or 0.7 N). The scaler tips were used at 0° angulation in relation to the dentin surfaces with water cooling according to the manufacturer's instructions. The stepper motor moved the mounted handpiece at a constant speed (2.5 mm/s) in a reciprocal motion (three times forwards and backwards) over the test area.

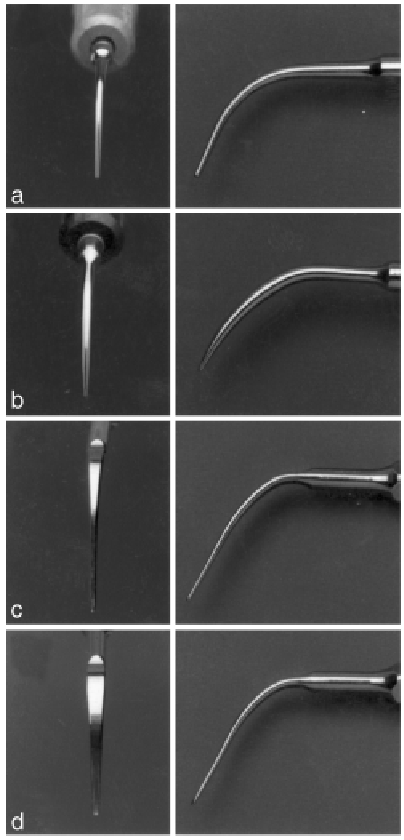

Fig. 1. Frontal and lateral aspects of the four different scaler tips evaluated in the present study. (a) Slimline, (b) TFI-10, (c) Perioprobe, (d) Type-A.

Quantification of root substance removal

Following instrumentation, the root specimens were washed and dried. An impression was taken (President light body, Coltene, Alstätten, Switzerland) and replicas (Stycast 1266, Grace) of the surfaces were cast. Replicas were sputtered with a 200 Å thick gold layer, mounted on an SEM plate, which was connected to an *x–y* table and aligned horizontally to the laser profilometer. The measurements were performed with an optical, non-contact profilometer system (UB16, UBM, Ettlingen, Germany), which used a laser as an optical stylus. The light beam (780 nm, spot size 1 μm) was focused by a wide-aperature objective onto the surface. The light reflected from the surface was collected by a photodetector, which received the maximum signal when the surface was at the focal point. Every time the laser beam was out of focus, a vertical movement of the objective occurred until the focal point was settled again. The vertical movement of the objective was recorded. The vertical resolution was ± 0.01 μm. The lateral resolution of the optical system was 1 μm and the lateral resolution of the table was 2 μm. The profilometric analysis was performed perpendicular to the traces of the instrumentation with 10 parallel measurements in a distance of 0.2 mm per test area.

Statistical analysis

The determination of root substance loss was based on the ''mean line'' according to the British roughness standard 1134. Outcome variables computed by the laser profilometric software (UB-SOFT Version 2.4, UBM) were defect width, defect depth and defect volume averaged over the entire scaled dentin

Table 1. The ultrasonic scalers and scaler tip designs used in the present study

System	Brand	Frequency (kHz)	Mode of action	Tip
Piezon Master 400	EMS	28	piezoelectric	Type-A Perioprobe
Cavi-Med 200	Dentsply	25	magnetostrictive	TFI-10 Slimline

surface. The differences between the treatment modalities were analysed by the Games–Howell M-ANOVA test. The significance level was set at $p<0.05$.

Results

The mean values computed for defect width, defect depth and defect volume are presented in Tables 2–4.

The mean defect width resulting from ultrasonic scaling ranged from 254.4 μm for the Cavi-Med 200/Slimline to 759.0 μm for the Cavi-Med 200/TFI-10 combination at a lateral force of 0.3 N, and from 383.2 μm for the Cavi-Med 200/Slimline to 851.8 μm for the Cavi-Med 200/TFI-10 combination at a lateral force of 0.7 N. Only slight differences were seen between both scaler tips that were operated by the piezoelectric device (Table 2).

The mean defect depth ranged from 6.3 μm for Cavi-Med 200/Slimline to 23.5 μm for Cavi-Med 200/TFI-10 at a lateral force of 0.3 N, and from 7.4 to 55.9 μm at 0.7 N, respectively. Again, values for the scaler tips driven by the Piezon Master ranged between the results for the magnetostrictive device, however, differed significantly from each other. As for the magnetostrictive device, higher defect depths resulted from the wider scaler tip (Table 3).

The mean defect volumes varied between 22.5 μm^3 for Cavi-Med 200/Slimline and 160.2 μm^3 for Cavi-Med 200/TFI-10 at 0.3 N, and from 70.8 to 336.8 μm^3 at 0.7 N. Intermediate results were observed following instrumentation with the piezoelectric device, with significantly higher values following the use of Type-A inserts (Table 4).

Overall, with increasing application forces from 0.3 to 0.7 N, the aggressiveness to the root dentin as assessed by defect depth, defect width and defect volume increased for all tested instrumentations by a factor of 1–2*x*.

Table 2. Mean (standard deviation) defect widths (μm) for ultrasonic scaler and scaler tip combinations

Force (N)	Instrument	Subgroup with $\alpha<0.05$*			
		1	2	3	4
0.3	Cavi Med 200/Slimline	254.4 (22.2)			
	Piezon Master 400/Perioprobe		352.0 (13.0)		
	Piezon Master 400/Type-A			402.4 (10.0)	
	Cavi Med 200/TFI-10				759.0 (25.1)
0.7	Cavi Med 200/Slimline	383.2 (17.3)			
	Piezon Master 400/Perioprobe		582.6 (40.6)		
	Piezon Master 400/Type-A		618.0 (9.4)		
	Cavi Med 200/TFI-10			851.8 (19.6)	

For each treatment, $n=5$.
*Games–Howell M-ANOVA test.

Table 3. Mean (standard deviation) defect depths (μm) for the ultrasonic scaler and scaler tip combinations

Force (N)	Instrument	Subgroup with $\alpha<0.05$*			
		1	2	3	4
0.3	Cavi Med 200/Slimline	6.3 (0.1)			
	Piezon Master 400/Perioprobe		12.1 (0.2)		
	Piezon Master 400/Type-A			14.0 (0.3)	
	Cavi Med 200/TFI-10				23.5 (0.6)
0.7	Cavi Med 200/Slimline	7.4 (0.0)			
	Piezon Master 400/Perioprobe		16.2 (0.3)		
	Piezon Master 400/Type-A			22.2 (1.0)	
	Cavi Med 200/TFI-10				55.9 (0.4)

For each treatment, $n=5$.
*Games–Howell M-ANOVA test.

Table 4. Mean (standard deviation) defect volumes (μm^3) for the ultrasonic scaler and scaler tip combinations

Force (N)	Instrument	Subgroup with $\alpha<0.05$*			
		1	2	3	4
0.3	Cavi Med 200/Slimline	22.5 (1.0)			
	Piezon Master 400/Perioprobe		56.4 (0.6)		
	Piezon Master 400/Type-A			133.4 (0.4)	
	Cavi Med 200/TFI-10				160.2 (1.0)
0.7	Cavi Med 200/Slimline	70.8 (0.4)			
	Piezon Master 400/Perioprobe		96.6 (1.6)		
	Piezon Master 400/Type-A			254.4 (5.2)	
	Cavi Med 200/TFI-10				336.8 (11.8)

For each treatment, $n=5$.
*Games–Howell M-ANOVA test.

Discussion

Since ultrasonic scalers are often considered to be less strenuous for the operator and more comfortable for the patients than hand curettes, they have become increasingly popular for subgingival debridement. The difficulties of carrying out adequate root debridement, coupled with the need to prevent reinfection of a pocket by periodic professional cleaning may cause a major loss of root substance over time.

There appears to be general agreement in the literature that hand instrumentation may lead to more loss of root substance than ultrasonic instrumentation, irrespective of the study design (Ritz et al. 1991, Dragoo et al. 1992, Jacobson et al. 1994, Rees et al. 1999, Busslinger et al. 2001, Schmidlin et al. 2001). Standardization of experimental conditions with respect to treatment modalities and surface analysis is important in studies that evaluate the effects of instrumentation on root surfaces. Earlier in vitro studies demonstrated that working parameters such as power setting, lateral force and tip angulation determine the amount of root damage by ultrasonic instrumentation (Flemmig et al. 1998a, b). In the present study, the power of the ultrasonic devices was set at a medium level, which was recommended by Flemmig et al. (1998a, b) for clinical practice.

The lateral forces used in the present study of 0.3, 0.7 N were comparable with the application forces used by Ritz et al. (1991), 0.98 N, by Flemmig et al. (1998a, b), 0.5–2 N and by Schmidlin et al. (2001), 0.4 N. Nevertheless, the analysis of the published reports indicated that there is still a need to establish standards for in vitro tests to measure tooth substance loss in the emerging field of power-driven root instrumentation. Because some studies determined the endpoint of instrumentation by time and others by the number of working strokes, the data reported in the literature were difficult to compare with the data of the present study.

Defect depth and defect volume on the instrumented dentin surface appear to be the most meaningful parameters for clinical implications regarding surface alterations. Interestingly, in the present study the lowest substance loss as well as the most severe damage to the root surfaces were both observed for the magnetostrictive device, the only difference being the tip used. This may indicate that the magnetostrictive ultrasonic unit was more sensible to changes of the scaler tip design than the piezoelectric unit with respect to root surface damage. The tip movement of a magnetostrictive unit ranges from nearly linear, to elliptical or circular (Drisko et al. 2000). In contrast, the oscillation pattern of a piezoelectric ultrasonic unit produces a tip movement that is primarily linear in direction. One may speculate that the observed variations of root surface alterations were because of the more complex movement of the magnetostrictive unit as compared with the piezoelectric ultrasonic unit, although Lea et al. (2003) demonstrated that with medium power settings the displacement amplitude of the tips were generally higher for piezoelectric than for magnetostrictive devices. The clinician has to be aware that changing the scaler tip attached to a magnetostrictive or piezoelectric ultrasonic device may have a great impact on the aggressiveness of the root surface treatment provided. These findings are in agreement with Kocher et al. (2001), who reported variable substance loss produced by different working tips when examining sonic scalers.

The measurements of the defect width in the present study, which ranged for individual combinations of ultrasonic units and scaler tips between 200 and 800 μm, may give an indication for the clinical efficacy of root planing with different ultrasonic devices. The interpretation of the defect width as the area instrumented by a single movement from apical to coronal showed that the same root area covered by one movement of the Cavi-Med 200/TFI-10 combination would require four strokes of the Cavi-Med 200/Slimline combination. In other words, the time needed for a complete instrumentation of the root surface with ultrasonic devices is significantly influenced by the tip design used. Therefore, future studies will have to determine whether the less aggressive narrow probe-shaped scaler inserts can accomplish the same efficacy in calculus removal and lead to the same improvement in clinical conditions.

In conclusion, distinct and consistent differences, which were statistically significant, were observed for the four ultrasonic scaler tips under study. For all parameters examined under the selected experimental conditions, a significant increase in the aggressiveness to root dentin was seen for wide scaler tips as compared with narrow probe-shaped instruments. These differences were particularly apparent for the magnetostrictive ultrasonic system. The present investigation showed that in addition to established working parameters like power setting, lateral force and tip angulation, the aggressiveness of magnetostrictive or piezoelectric ultrasonic devices is significantly influenced by the scaler tip design.

References

Badersten, A., Nilveus, R. & Egelberg, J. (1981) Effect of nonsurgical periodontal therapy. I. Moderately advanced periodontitis. *Journal of Clinical Periodontology* **8**, 57–72.

Badersten, A., Nilveus, R. & Egelberg, J. (1984) Effect of nonsurgical periodontal therapy. III. Single versus repeated instrumentation. *Journal of Clinical Periodontology* **11**, 114–124.

Breininger, D. R., O'Leary, T. J. & Blumenshine, R. V. (1987) Comparative effectiveness of ultrasonic and hand scaling for the removal of subgingival plaque and calculus. *Journal of Periodontology* **58**, 9–18.

Busslinger, A., Lampe, K., Beuchat, M. & Lehmann, B. (2001) A comparative in vitro study of a magnetostrictive and a piezoelectric ultrasonic scaling instrument. *Journal of Clinical Periodontology* **28**, 642–649.

Dragoo, M. R. (1992) A clinical evaluation of hand and ultrasonic instruments on subgingival debridement. 1. With unmodified and modified ultrasonic inserts. *International Journal of Periodontics and Restorative Dentistry* **12**, 310–323.

Drisko, C. L., Cochran, D. L., Blieden, T., Bouwsma, O. J., Cohen, R. E., Damoulis, P., Fine, J. B., Greenstein, G., Hinrichs, J., Somerman, M. J., Iacono, V. & Genco, R. J. (2000) Position paper: sonic and ultrasonic scalers in periodontics. Research, Science and Therapy Committee of the American Academy of Periodontology. *Journal of Periodontology* **71**, 1792–1801.

Flemmig, T. F., Petersilka, G. J., Mehl, A., Hickel, R. & Klaiber, B. (1998a) Working parameters of a magnetostrictive ultrasonic scaler influencing root substance removal in vitro. *Journal of Periodontology* **69**, 547–553.

Flemmig, T. F., Petersilka, G. J., Mehl, A., Hickel, R. & Klaiber, B. (1998b) The effect of working parameters on root substance removal using a piezoelectric ultrasonic scaler in vitro. *Journal of Clinical Periodontology* **25**, 158–163.

Gankerseer, E. J. & Walmsley, A. D. (1987) Preliminary investigation into the performance of a sonic scaler. *Journal of Periodontology* **58**, 780–784.

Jacobson, L., Blomlof, J. & Lindskog, S. (1994) Root surface texture after different scaling modalities. *Scandinavian Journal of Dental Research* **102**, 156–160.

Kocher, T., Fanghanel, J., Sawaf, H. & Litz, R. (2001) Substance loss caused by scaling with different sonic scaler inserts – an in vitro study. *Journal of Clinical Periodontology* **28**, 9–15.

Lea, S. C., Landini, G. & Walmsley, A. D. (2003) Displacement amplitude of ultrasonic scaler inserts. *Journal of Clinical Periodontology* **30**, 505–510.

Rees, J. S., Addy, M. & Hughes, J. (1999) An in vitro assessment of the dentine lost during instrumentation using the Periosonic system. *Journal of Clinical Periodontology* **26**, 106–109.

Ritz, L., Hefti, A. F. & Rateitschak, K. H. (1991) An in vitro investigation on the loss of root substance in scaling with various instruments. *Journal of Clinical Periodontology* **18**, 643–647.

Schmidlin, P. R., Beuchat, M., Busslinger, A., Lehmann, B. & Lutz, F. (2001) Tooth substance loss resulting from mechanical, sonic and ultrasonic root instrumentation assessed by liquid scintillation. *Journal of Clinical Periodontology* **28**, 1058–1066.

Tunkel, J., Heinecke, A. & Flemmig, T. F. (2002) A systematic review of efficacy of machine-driven and manual subgingival debridement in the treatment of chronic periodontitis. *Journal of Clinical Periodontology* **29** (Suppl. 3), 72–81.

Address:
Søren Jepsen
Department of Periodontology, Operative and Preventive Dentistry
University of Bonn
Welschnonnenstr. 17
53111-Bonn
Germany
E-mail: jepsen@uni-bonn.de