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Periodontal healing after non-surgical therapy with a modified sonic scaler: a controlled clinical trial

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Abstract

Aim: The aim of this study was to compare the clinical and microbiological healing outcomes following non-surgical periodontal therapy using a modified sonic scaler system *versus* scaling and root planing (S/RP) with hand instruments.

Material and Methods: The study comprised 20 chronic periodontitis patients. Using a split-mouth design, both treatment modalities were randomly applied to one quadrant of the upper and lower jaws. Clinical and microbiological parameters were assessed at baseline, 4 weeks, and 6 months after treatment. Furthermore, post-operative hypersensitivity was investigated. The Wilcoxon signed-rank test ($\alpha = 0.05$) was used for statistical analysis.

Results: With both therapy methods, periodontal conditions showed statistically significant clinical and microbiological improvements after 4 weeks and 6 months. Hypersensitive teeth were found only 4 weeks after S/RP. Besides a significantly better bleeding on probing reduction in deep S/RP sites and less time required for root instrumentation by the sonic scaler, no other clinical and microbiological parameters revealed significant differences between sites treated with the sonic scaler or S/RP.

Conclusion: The sonic scaler system and S/RP seem to provide similarly favourable periodontal healing results, although in deep pockets S/RP appeared to achieve a better resolution of inflammation.

Key words: bacteria; clinical trials; periodontal therapy; periodontitis; scaler/non-surgical periodontal therapy; sonic; ultrasonic

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Bacterial infection plays a key role in the aetiology and pathogenesis of periodontitis (Haffajee & Socransky 1994, Socransky et al. 1998). Within the periodontal pocket, bacteria are organized as a biofilm adhering to root surfaces (Darveau et al. 1997). Bacterial endotoxines and other antigenic components often stimulate the host response, causing inflammation and periodontal tissue destruction (Page et al. 1997). Therefore, debridement of the subgingival plaque must be the main goal in the treatment of inflammatory periodontal disease (Wennström et al. 2005). Numerous studies have shown that plaque removal leads to the resolution of inflammation and can prevent further progression of the destruction process (Knowles et al. 1979, Lindhe & Nyman 1984, Cobb 1996, Van der Weijden & Timmerman 2002, Müller & Heinecke 2004). While different treatment methods are available for subgingival debridement, hand instrumentation with curettes is still regarded as the gold standard (AAP Position Paper 2000, Tunkel et al. 2002). Besides machine-driven instruments (e.g. sonic and ultrasonic scalers), rotating, reciprocating, and laser instruments are available (AAP Position Paper 2000). According to the literature, the choice of treatment modality seems to be less important for the treatment outcome than the detailed thoroughness of the root surface debridement and the patient's standard of oral hygiene (Cobb 1996). Sonic or ultrasonic scalers seem to be similarly effective as manual debridement regarding clinical attachment gain, probing pocket depth (PPD) reduction, and bleeding on probing (BOP) reduction (Badersten et al. 1981, 1984, Copulos et al. 1993, Kocher et al. 2001b, Tunkel et al. 2002, Hallmon & Rees 2003, Suvan 2005). This was also confirmed by a recent *in vitro* study (Khosravi et al. 2004).

Previous studies have demonstrated that there is no rationale for intentional removal of root substance by root planing

to achieve periodontal healing (Hughes & Smales 1986, Hughes et al. 1988, Cadosch et al. 2003). Consequently, instruments for subgingival debridement should be effective in disrupting the biofilm and removing bacterial deposits from the root surface with only minimal loss of tooth substance (Obeid & Bercy 2005, Wennström et al. 2005).

Sonic scalers are air-driven instruments, which produce vibrations in the sonic range (2000–6000 Hz). They seem to cause less tooth substance loss than hand curettes (Ritz et al. 1991, Schmidlin et al. 2001). With special slim, probe shaped tips, anatomically difficult areas can be treated more effectively than with hand curettes (AAP Position Paper 2000). Furthermore, in sonic and ultrasonic scalers, probe shaped, round inserts keep the loss of tooth substance to a minimum (Flemmig et al. 1997, Kocher et al. 2001a, Jepsen et al. 2004). The new SonicFlex 2003L scaler (KaVo, Biberach, Germany) is a modification of a previously used airscaler. A light source of 12,000 Lx and different power levels are newly developed features of this sonic scaler. It is not clear whether the safety and efficiency of the SonicFlex scaler can be regulated by the power adjustment of the handpiece (Petersilka & Flemmig 2004).

Only a few studies have investigated the effectiveness of sonic scalers in reducing periodontal pathogens (Oosterwaal et al. 1987, Schenk et al. 2000). Furthermore, to the best of our knowledge, there has been no study that examined unwanted side effects like post-operative hypersensitivity following periodontal treatment with sonic scalers in comparison with hand instrumentation. The aim of the present clinical split-mouth study was to investigate the clinical and microbiological healing outcomes following non-surgical periodontal treatment using the modified sonic scaler system SonicFlex 2003L in comparison with scaling and root planing (S/RP) with hand curettes. Furthermore, the time required for root instrumentation as well as the occurrence of negative side effects for the patients (post-operative hypersensitivity) should be addressed.

Material and Methods

Study design

This study was designed as a randomized prospective-controlled clinical split-mouth study comparing the clinical and microbiological healing outcomes after periodontal treatment with either a modified sonic scaler system (*test group*) or S/RP with hand instruments (*control group*). The study design was approved by the ethics committee of the University of Regensburg in accordance with the Declarations of Helsinki (1975) and Tokyo (1983). All patients received a detailed description of the proposed treatment for informed and written consent.

Patient selection

The study comprised 20 patients (14 females, six males) with a median age of 46 years. The patients were recruited from the patient pool of the Department of Operative Dentistry and Periodontology at the University of Regensburg. All had generalized moderate to progressive chronic periodontitis, but were systemically healthy and had not received systemic antibiotics for at least 3 months before. Each patient had to show at least four teeth per quadrant with a PPD of at least 4 mm. Five of the 20 patients (25%) were active smokers, smoking eight cigarettes per day on average (Table 1).

Table 1. Patient characteristics

	20 patients
Gender (*n*)	
Female	14
Male	6
Age (years)	
Median	46.0
25/75%	39.3/51.8
Mean ± SD	45.6 ± 8.0
Smoking (*n*)	
Active smokers	5
Former smokers	9
Non-smokers	6
Active smokers: cigarettes per day	
Median	8.0
25/75%	5.0/11.5
Mean ± SD	8.2 ± 3.6

n, number of patients; median, median value; 25/75%, 25/75% percentile; mean, mean value; SD, standard deviation.

Fig. 1. SonicFlex 2003L with the possibility of different power settings (arrow).

Therapeutic procedures

After the first visit and before the baseline examination, each patient followed an initial pre-treatment phase consisting of oral hygiene instructions, supragingival scaling, filling of decayed teeth, extraction of hopeless teeth, and splinting of extremely mobile teeth. Two weeks after completion of this pre-treatment and control of each patient's compliance (i.e. approximal plaque index (API) and papillary bleeding index (PBI) $\leqslant$ 25%), subgingival debridement of all teeth was carried out within 24 h to avoid re-infection of treated sites from the untreated sites. Applying the split-mouth design, one quadrant of the upper and lower jaws were randomly selected applying a random number table, which was generated in advance using SPSS software version 11.5 (SPSS Inc., Chicago, IL, USA), for treatment with either the modified sonic scaler system SonicFlex 2003L (KaVo) (Fig. 1) or hand curettes (Gracey-curettes #1/2, #7/8, #11/12, #13/14, HuFriedy, Chicago, IL, USA). The power of the sonic scaler was set to level 2 (amplitude: 150 μm; frequency: 6000 Hz; volume: 69 dB). For the subgingival instrumentation, the SonicFlex Paro tips # 60, 61, and 62 with a round cross-section (Fig. 2) were used. Local anaesthesia was provided on demand. The time required for instrumentation of each quadrant was recorded by a stop watch. The criterion for a thorough subgingival debridement was a smooth root surface free of bacterial plaque and calculus verified by a dental explorer (CH3, HuFriedy) and 2 × -magnifying lenses. Finally, all periodontal pockets were rinsed with a 0.2% chlorhexidine solution. Four weeks and 6 months after therapy, the patients were scheduled for re-evaluation and

Fig. 2. Tips # 60, 61, 62 for SonicFlex 2003L.

supportive periodontal therapy. At these time points, subgingival re-instrumentation was planned only in sites that showed signs of major inflammation (e.g. suppuration, swelling), which could not be left untreated until the completion of the study. After 6 months, all patients were assigned according to the individual needs to a 3–6-month schedule for supportive periodontal therapy in the Department of Operative Dentistry and Periodontology.

Clinical examinations

The following parameters were recorded at the first visit, immediately before subgingival debridement (i.e. baseline) as well as 4 weeks and 6 months after instrumentation: oral hygiene was assessed by the full-mouth approximal PI (API) (Lange et al. 1977) and the full-mouth PBI (Saxer & Mühlemann 1975). The full-mouth API was calculated as the percentage of inter-proximal sites depicting plaque. The full-mouth PBI was calculated as the percentage of inter-proximal sites demonstrating bleeding after gentle probing. The following clinical parameters were recorded: gingival recession (REC) as the distance between the cementoenamel junction (CEJ) or the margin of a restoration and the free gingival margin; PPD as the distance from the gingival margin to the bottom of the periodontal pocket; and clinical attachment level (CAL) as the distance from the CEJ to the bottom of the periodontal pocket. Furthermore, BOP (Lang et al. 1991) was calculated as the percentage of sites bleeding upon gentle probing. All parameters (REC, PPD, CAL, and BOP) were recorded at six sites on each tooth: mesiobuccal, buccal, distobuccal, mesiolingual, lingual and distolingual. A pressure-calibrated probe (Brodontic 25g, Ash, Dentsply, Weybridge, UK) with a PCP15-UNC tip (HuFriedy) provided standardized probing conditions. All clinical parameters were recorded masked by one calibrated examiner (S. B.), who had no knowledge of the treatment modality chosen for the individual tooth. Before the start of the study, the examiner was trained to adequate levels of accuracy and reproducibility in recording the clinical parameters and indices.

Assessment of the negative side effects

As a parameter for the patient's discomfort, all patients were asked about the occurrence of post-operative hypersensitivity (subjective post-operative hypersensitivity) after 4 weeks and 6 months. Furthermore, the objective post-operative hypersensitivity was assessed with air-blast pain stimuli as described previously (Tammaro & Wennström 2000). The air-blast (4.1 bar, 22°C) derived from the syringe of a dental delivery unit was directed to the buccal root surface for a maximum of 10 s. The syringe was held perpendicularly, 5 mm from the root surfaces. The neighbouring teeth were shielded with the gloved fingers of the dentist. The number of teeth revealing a subjective or objective pain sensation was recorded dichotomously after 4 weeks and 6 months.

Microbiological examination

At baseline, as well as 4 weeks and 6 months after subgingival debridement, subgingival bacterial samples were obtained from the deepest site in each quadrant. For this purpose, a molecular-biological testing system (Padotest 4.5, Institute for applied Immunology (IAI), Zuchwil, Switzerland) was used. The sample sites were isolated with cotton rolls, air-dried, and supragingival plaque or calculus was removed, if present, with sterile scalers. One medium-sized sterile paper point (absorbent points, Johnson & Johnson, Medical Inc., Arlington, TX, USA) was inserted into the bottom of the periodontal pocket. After 20 s, the paper point was retrieved and transferred to tight-sealing screw-cap tubes containing 100 μL of a nucleic-acid preserving buffer and mailed to the IAI laboratory. In this way, two samples each were retrieved from the test and control sites. Both test samples and both control samples were pooled in one collection tube each. The samples were analysed by chemiluminescence-tagged probes for the small subunit ribosomal RNAs (ssrRNA probes) (Dix et al. 1990) for *Actinobacillus actinomycetemcomitans*, *Tanerella forsythensis*, *Porphyromonas gingivalis*, and *Treponema denticola*. Each probe comprised a mix of three oligonucleotides specific for the corresponding bacterial species. Furthermore, the total marker load (TML) (number of periodontal pathogens related to the total number of bacteria in the sample) and the total bacterial load (TBL) (total amount of bacteria in the sample) were determined. The determination of the TML was carried out by using a universal bacterial probe comprising a mix of three oligonucleotides specific for the most conserved regions of the bacterial ssrRNA, which can be found in all bacteria.

Data analysis

The patient was regarded as the evaluation unit. Clinical and microbiological measurements were expressed as median values (with 25 and 75 percentiles). Taking into account the paired nature of the split-mouth design, the Wilcoxon Signed Rank test was used for the statistical analysis of differences between the treatment modalities and between the examination times. The significance level was set to $\alpha = 0.05$. For comparability with other studies, additionally, the mean values and standard deviations were included in the tables. The results of the negative side effects were reported descriptively.

Owing to their different healing response (Badersten et al. 1984, Van der Weijden & Timmerman 2002), the periodontal pockets were divided into three different PPD categories on the basis of the initial PPDs: shallow pockets (initial PPD: 1–3 mm), moderate pockets (initial PPD: 4–6 mm), and deep pockets (initial PPD: $\geqslant$7 mm).

Results

All 20 patients completed the 6-month evaluation. The patient characteristics are reported in Table 1. At the 4-week and 6-month evaluation, none of the patients revealed any major periodontal inflammatory symptoms requiring re-instrumentation during the entire study period. No tooth under investigation had to be extracted. A similar number of teeth were treated with the sonic scaler and S/RP (248 *versus* 260). Both groups showed a similar distribution of the periodontal pocket depth categories (Table 2) and of the tooth types (Table 3).

Clinical results

The clinical results are reported in Tables 4–7. At baseline, none of the clinical parameters (BOP, PPD, CAL) revealed any statistically significant differences between test and control sites.

Oral hygiene and gingival health

Two weeks after completion of the supragingival pre-treatment phase, all patients showed adequate compliance with good oral hygiene at baseline. The full-mouth API was 14.0% and the PBI was 17.0%. Four weeks and 6 months after subgingival debridement, the full-mouth API remained stable without statistically significant differences compared with baseline. The full-mouth PBI decreased further to 9.5% (4 weeks) and 9.0% (6 months) (Table 4).

Table 2. Relative distribution of probing pocket depth categories per patient.

Pocket depth category	Test sites (%)	Control sites (%)
Shallow pockets (1–3 mm)		
Median	56.9	54.2
25/75%	37.3/69.9	40.5/72.2
Mean ± SD	55.4 ± 19.6	54.8 ± 20.4
Moderate pockets (4–6 mm)		
Median	38.9	35.8
25/75%	29.4/49.6	24.5/45.6
Mean ± SD	37.8 ± 14.7	36.8 ± 14.5
Deep pockets (⩾7 mm)		
Median	6.0	6.1
25/75%	3.9/14.9	3.7/12.6
Mean ± SD	10.0 ± 9.7	11.5 ± 14.9

Test sites, SonicFlex-treated sites; control sites, scaling and root planing-treated sites; 25/75%, 25/75% percentile; mean, mean value; SD, standard deviation.

Table 3. Distribution of tooth categories

Tooth category	Test teeth (%)	Control teeth (%)
Incisors and canines	45.3	45.3
Pre-molars	29.9	28.3
Molars	24.8	26.4

Test teeth, SonicFlex-treated teeth; control teeth, scaling and root planing-treated teeth.

Table 4. Full-mouth indices API and PBI

	API (%)	PBI (%)
First visit		
Median	77.5	35.5
25/75%	60.3/91.0	25.0/46.8
Mean ± SD	74.2 ± 20.9	36.6 ± 16.4
Baseline		
Median	14.0*	17.0*
25/75%	11.3/19.0	9.3/21.5
Mean ± SD	17.7 ± 16.8	16.9 ± 8.9
4 weeks		
Median	13.0*	9.5*
25/75%	1.0/25.5	5.5/18.3
Mean ± SD	16.8 ± 16.9	11.7 ± 9.3
6 months		
Median	15.5*	9.0*†
25/75%	4.0/23.8	6.0/17.5
Mean ± SD	14.9 ± 12.4	11.8 ± 10.5

*Statistically significant difference compared with first visit.
†Statistically significant difference compared with baseline.
25/75%, 25/75% percentile; mean, mean value; SD, standard deviation; first visit, before supragingival cleaning; baseline, 2 weeks after supragingival cleaning; 4 weeks, 4 weeks after subgingival debridement; 6 months, 6 months after subgingival debridement; API, approximal plaque index; PBI, papillary bleeding index.

BOP

Four weeks and 6 months after subgingival debridement, statistically significant BOP reductions compared with baseline were observed in both treatment groups and for all three-pocket depth categories (Table 5). In the moderate pockets, the baseline BOP of about 76% was reduced by more than 60% in both treatment groups after 4 weeks and 6 months. In the deep pockets, the BOP was 100.0% in both groups at baseline. In the test group, a reduction of 70.8% after 4 weeks and of 66.7% after 6 months was found. In the control group, the reduction was 75.0% and 75.6% after 4 weeks and 6 months, respectively. After 6 months, deep control sites revealed a significantly better BOP reduction compared with deep test sites.

PPD

Both test and control procedures yielded statistically significant PPD reductions after 4 weeks and 6 months compared with baseline, especially in the moderate and deep pockets (Table 6). In moderate pockets, a median PPD reduction of 1.0 mm was found after 4 weeks and 6 months in both treatment groups. In deep pockets, the test procedure provided a PPD reduction of 2.0mm and 1.8 mm after 4 weeks and 6 months, respectively. The control procedure achieved a PPD reduction of 2.0 mm after 4 weeks and 6 months. No significant differences were found between test and control sites.

CAL

While shallow pockets did not reveal significant CAL changes following subgingival debridement, both test and control procedures provided statistically significant CAL gains of 1.0 mm in moderate and deep pockets (except 0.8 mm in moderate test sites after 4 weeks) (Table 7). The only statistically (but not clinically) significant difference between test and control sites was found in moderate pockets after 6 months.

None of the clinical parameters revealed a statistically significant influence of the tooth type (incisors/canines, pre-molars, molars) on the effectiveness of the test or control procedure (data not shown).

Microbiological results

The microbiological results are reported in Table 8. The bacterial findings were

Table 5. Bleeding on probing (BOP) (%): baseline value (BL) and changes (*Δ*BOP) at the various examination intervals

	Test group ($n = 20$)			Control group ($n = 20$)		
	BOP baseline	ΔBOP 4 weeks–BL	ΔBOP 6 months–BL	BOP baseline	ΔBOP 4 weeks–BL	ΔBOP 6 months–BL
Shallow pockets (1–3 mm)						
Median	30.7	− 24.8*	− 27.5*	28.2	− 22.2*	− 21.5*
25/75%	20.0/38.7	− 34.5/ − 11.1	− 35.6/ − 14.8	19.8/39.5	− 38.9/ − 13.8	− 39.5/ − 17.3
Mean ± SD	33.6 ± 19.9	− 27.5 ± 22.6	− 29.8 ± 19.4	32.5 ± 16.2	− 26.9 ± 17.4	− 29.6 ± 17.3
Moderate pockets (4–6 mm)						
Median	76.6	− 61.9*	− 61.3*	75.8	− 64.1*	− 64.6*
25/75%	63.5/87.9	− 76.4/ − 44.5	− 78.2/ − 55.1	67.3/87.9	− 77.1/ − 45.8	− 78.8/ − 48.3
Mean ± SD	76.0 ± 14.8	− 60.8 ± 19.6	− 65.5 ± 17.0	76.0 ± 16.0	− 61.8 ± 18.0	− 63.3 ± 17.1
Deep pockets (⩾7 mm)						
Median	100.0	− 70.8*	− 66.7*†	100.0	− 75.0*	− 75.6*†
25/75%	97.9/100.0	− 86.2/ − 45.8	− 78.3/ − 25.0	99.9/100.0	− 100.0/ − 60.0	− 100.0/ − 50.0
Mean ± SD	95.2 ± 10.2	− 60.4 ± 31.7	− 57.3 ± 35.0	96.3 ± 9.7	− 74.3 ± 21.7	− 75.9 ± 22.3

*Statistically significant change compared with baseline.
†Statistically significant difference between test and control group.
Test group, SonicFlex-treated teeth; control group, S/RP-treated teeth; *n*, number of patients treated in test or control group; 25/75%, 25/75% percentile; mean, mean value; SD, standard deviation.

Table 6. Probing pocket depth (PPD) (mm): baseline value (BL) and changes (*Δ*PPD) at the various examination intervals

	Test group ($n = 20$)			Control group ($n = 20$)		
	PPD baseline	ΔPPD 4 weeks–BL	ΔPPD 6 months–BL	PPD baseline	ΔPPD 4 weeks–BL	ΔPPD 6 months–BL
Shallow pockets (1–3 mm)						
Median	2.3	0.0†	0.0†	2.0	0.0	0.0†
25/75%	2.0/3.0	0.0/0.0	0.0/0.0	2.0/3.0	0.0/0.0	0.0/0.0
Mean ± SD	2.5 ± 0.5	0.1 ± 0.3	0.0 ± 0.0	2.4 ± 0.5	0.1 ± 0.3	0.0 ± 0.1
Moderate pockets (4–6 mm)						
Median	4.5	− 1.0†	− 1.0†	4.0	− 1.0†	− 1.0†
25/75%	4.0/5.0	− 1.0/0.0	− 1.0/0.0	4.0/5.0	− 1.0/ − 1.0	− 1.0/ − 1.0
Mean ± SD	4.6 ± 0.6	− 0.8 ± 0.6	− 0.9 ± 0.7	4.5 ± 0.6	− 0.9 ± 0.5	− 1.1 ± 0.6
Deep pockets (⩾7 mm)						
Median	8.0	− 2.0†	− 1.8†	7.0	− 2.0†	− 2.0†
25/75%	7.0/8.1	− 3.0/ − 1.0	− 3.3/ − 1.0	7.0/8.0	− 2.0/ − 1.0	− 3.0/ − 1.0
Mean ± SD	7.9 ± 0.9	− 2.0 ± 1.1	− 2.0 ± 1.4	7.7 ± 1.3	− 2.0 ± 1.4	− 2.4 ± 1.8

†Statistically significant change compared with baseline.
Test group, SonicFlex-treated teeth; control group, S/RP-treated teeth; *n*, number of patients treated in test or control group; 25/75%, 25/75% percentile; mean, mean value; SD, standard deviation.

very similar in test and control sites at baseline as well as 4 weeks and 6 months after therapy.

Microbiological testing detected *A. actinomyctemcomitans* in only very few sites and could not reveal significant changes following therapy. In contrast, in both treatment groups, the numbers of *T. forsythensis*, *P. gingivalis*, and *T. denticola* were significantly reduced after 4 weeks and 6 months compared with the baseline situation. Between the 4-week and 6-month examinations, a slight but significant increase was found again for *T. denticola* in test sites as well as for *T. forsythensis* in both test and control sites.

The TBL was reduced from initially $22{,}190 \times 10^3$ *versus* $19{,}215 \times 10^3$ (test *versus* control) to 5885×10^3 *versus* $10{,}285 \times 10^3$ after 4 weeks and to $11{,}080 \times 10^3$ *versus* 4495×10^3 after 6 weeks. The TML decreased from 10.2% *versus* 9.7% (test *versus* control) at baseline to 0.8% *versus* 1.3% after 4 weeks and then significantly increased again to 5.5% *versus* 2.8% after 6 months. None of the microbiological parameters revealed statistically significant differences between test and control sites.

Time of instrumentation

Based on the described criteria for treatment completion, the median duration needed for root instrumentation per tooth was 4.3 min. with the sonic scaler and 6.1 min. with the curettes (S/RP). This difference was statistically significant.

Negative side effects

Four weeks after subgingival debridement, no tooth treated with the sonic scaler, but 3.6 teeth/patient (median) treated with S/RP showed subjective post-operative hypersensitivity as reported by the patient. At the same time, no tooth treated with the sonic scaler, but 7.1 teeth/patient (median) treated with S/RP showed objective post-operative hypersensitivity provoked by the air blast. Six months after subgingival debridement, neither the test nor the control teeth revealed a

Table 7. Clinical attachment level (CAL) (mm): baseline value (BL) and changes (*Δ*CAL) at the various examination intervals

	Test group ($n = 20$)			Control group ($n = 20$)		
	CAL baseline	ΔCAL 4 weeks–BL	ΔCAL 6 months–BL	CAL baseline	ΔCAL 4 weeks–BL	ΔCAL 6 months–BL
Shallow pockets (1–3 mm)						
Median	3.0	0.0	0.0	3.0	0.0	0.0
25/75%	2.6/3.0	0.0/0.0	0.0/0.0	2.0/3.0	0.0/0.0	0.0/0.0
Mean ± SD	2.8 ± 0.5	0.2 ± 0.4	0.1 ± 0.2	2.7 ± 0.6	0.1 ± 0.3	0.1 ± 0.4
Moderate pockets (4–6 mm)						
Median	5.0	−0.8*	−1.0*†	4.5	−1.0*	−1.0*†
25/75%	4.0/5.0	−1.0/0.0	−1.0/0.0	4.0/5.0	−1.0/0.1	−1.0/−1.0
Mean ± SD	4.8 ± 0.6	−0.6 ± 0.6	−0.8 ± 0.7	4.8 ± 0.9	−0.8 ± 0.5	−0.9 ± 0.5
Deep pockets (⩾7 mm)						
Median	8.0	−1.0*	−1.0*	7.5	−1.0*	−1.0*
25/75%	7.0/9.0	−2.1/−0.5	−2.0/−0.5	7.0/8.0	−2.0/−1.0	−2.0/−1.0
Mean ± SD	8.0 ± 1.0	−1.6 ± 1.0	−1.3 ± 1.2	7.9 ± 1.5	−1.5 ± 0.8	−1.8 ± 1.3

*Statistically significant change compared with baseline.
†Statistically significant difference between test and control group.
Test group, SonicFlex-treated teeth; control group, S/RP-treated teeth; *n*, number of patients treated in test or control group; 25/75%, 25/75% percentile; mean, mean value; SD, standard deviation.

Table 8. Microbiological results: number of tested bacteria, total bacterial load, and total marker load

	Test group ($n = 20$)			Control group ($n = 20$)		
	Baseline	4 weeks	6 months	Baseline	4 weeks	6 months
Actinobacillus actinomycetemcomitans ($\times 10^3$)						
Median	0	0	0	0‡	0	0‡
25/75%	0/0	0/0	0/0	0/11	0/0	0/0
Mean ± SD	7 ± 14	2 ± 11	8 ± 19	39 ± 124	12 ± 51	3 ± 8
Tanerella forsythensis ($\times 10^3$)						
Median	625†‡	10†§	250‡§	1040†‡	0†§	60‡§
25/75%	193/2788	0/88	13/540	43/2480	0/90	3/808
Mean ± SD	1683 ± 2069	154 ± 393	821 ± 2039	1401 ± 1410	94 ± 194	362 ± 549
Porphyromonas gingivalis ($\times 10^3$)						
Median	585†‡	0†	0‡	520†‡	0†	10‡
25/75%	88/1925	0/45	0/113	10/1868	0/78	0/155
Mean ± SD	1467 ± 2036	225 ± 877	179 ± 492	1725 ± 2923	42 ± 73	243 ± 507
Treponema denticola ($\times 10^3$)						
Median	505†‡	5†§	150‡§	380†	0†	35
25/75%	165/1120	0/128	13/423	53/1583	0/98	0/295
Mean ± SD	923 ± 1141	121 ± 299	261 ± 344	881 ± 1174	88 ± 196	189 ± 335
Total bacterial load ($\times 10^3$)						
Median	22,190†‡	5885†	11,080‡	19,215‡	10,285	4495‡
25/75%	12,568/41,183	3738/28,090	3823/15,795	8088/45,178	2668/20,293	2975/10,170
Mean ± SD	31,611 ± 29,288	15,387 ± 19,189	12,190 ± 12,692	31,988 ± 35,067	14,668 ± 16,010	7791 ± 6925
Total marker load (%)						
Median	10.2†‡	0.8†§	5.5‡§	9.7†	1.3†§	2.8§
25/75%	4.8/14.3	0.0/3.5	2.2/10.9	5.9/15.3	0.1/2.7	1.2/14.5
Mean ± SD	10.8 ± 7.6	2.3 ± 3.4	6.9 ± 6	10.5 ± 6.6	1.9 ± 1.9	6.9 ± 7.5

†Statistically significant difference between baseline and 4 weeks.
‡Statistically significant difference between baseline and 6 months.
§Statistically significant difference between 4 weeks and 6 months.
n, number of patients treated in test or control group; mean, mean value; SD, standard deviation; 25/75%, 25/75% percentile.

subjective or objective post-operative hypersensitivity.

Discussion

Subgingival debridement in conjunction with supragingival plaque control has proven to be effective in periodontal therapy (Van der Weijden & Timmerman 2002). The present study demonstrated that in patients with moderate to advanced chronic periodontitis, non-surgical periodontal therapy with a modified sonic scaler (SonicFlex 2003L) can result in similarly favourable clinical and microbiological healing results as conventional S/RP with hand curettes. This is in agreement with previous studies on machine-driven *versus* manual subgingival debridement (Tunkel et al. 2002, Hallmon & Rees 2003, Wennström et al. 2005).

The present study design facilitated the comparison of both treatment methods under very similar and optimally standardized healing and evaluation conditions. Owing the split-mouth

design, the patients served as their own controls, providing similar healing conditions and susceptibility for the recurrence of disease (Hujoel & Moulton 1988, Page et al. 1995, Koch & Paquette 1997). Both the test and control group comprised a similar number of teeth as well as a similar distribution of tooth types and PPD categories. Furthermore, none of the clinical and microbiological baseline parameters revealed any statistically significant differences. Although controversial (Kinane 2005, Koshy et al. 2005), full-mouth debridement was performed within 24 h to prevent possible reinfection of the treated sites from the remaining untreated sites (Quirynen et al. 1995, 2000).

A recent review demonstrated the effectiveness of subgingival debridement, if an adequate supragingival plaque control is established (Van der Weijden & Timmerman 2002). The goal of this study was to compare the effectiveness of the modified sonic scaler and conventional S/RP for the subgingival non-surgical debridement. The influence of the supragingival plaque control and patients' compliance should be kept minimal. For this reason, similar to previous studies (Laurell 1990, Brochut et al. 2005), a pre-treatment phase including supragingival cleaning and intensive oral hygiene instructions, was performed 2 weeks before the baseline examination. During the 6-month study period, all patients revealed low plaque and gingival bleeding scores.

One major goal of periodontal therapy is to remove the subgingival bacterial biofilm as far as possible and thus to reduce the bacterial load below a clinically and immunologically relevant threshold, allowing soft tissue healing (Cobb 1996, Van der Weijden & Timmerman 2002, Wennström et al. 2005). In the present study, both treatment methods caused significant reductions of three of the investigated periodontal pathogens (*T. forsysthensis*, *P. gingivalis*, *T. denticola*) as well as of the TBL 4 weeks and 6 months after subgingival debridement. This was in line with the significant improvements of the clinical healing parameters (BOP, PPD, CAL). However, especially in test sites a slight increase of the bacterial load between the 4-week and 6-month investigation indicated the beginning of a bacterial recolonization in the periodontal pockets. These observations are in accordance with previous findings (Pedrazzoli et al. 1991, Ali et al. 1992, Lowenguth & Greenstein 1995, Haffajee et al. 1997, Shiloah et al. 1997, Takamatsu et al. 1999, Doungdomdacha et al. 2001, Beikler et al. 2004, Brochut et al. 2005), which showed similar microbiological changes following non-surgical periodontal therapy.

One important aspect to assess the success of subgingival debridement is the effective reduction of periodontal inflammatory symptoms like BOP. In the present study, both treatment methods resulted in a marked BOP reduction of 61–76% in moderate and deep pockets after 4 weeks and 6 months. The only significant difference between the test and the control procedure was found in the deep pockets (PPD $\geqslant$ 7 mm) after 6 months, when the sonic scaler left a significantly higher residual BOP compared with the S/RP (ΔBOP: 66.7% *versus* 75.6%). The magnitude of the BOP reductions corresponds to previous studies summarized in recent reviews (Tunkel et al. 2002, Van der Weijden & Timmerman 2002, Hallmon & Rees 2003). In those studies, no difference was found between S/RP and machine-driven subgingival debridement (Badersten et al. 1981, 1984, Lindhe & Nyman 1985, Laurell & Pettersson 1988, Kalkwarf et al. 1989, Copulos et al. 1993, Kocher et al. 2001b, Obeid et al. 2004). In contrast, the present data indicated that S/RP may be more effective in the control of periodontal inflammation in deep periodontal pockets. The higher residual BOP in test sites after 6 months was in line with the increased bacterial load compared with the findings after 4 weeks and in control sites. One possible explanation may be the length of the sonic scaler tips, which may not have reached the fundus of deep pockets as effectively as of shallow and moderate pockets.

An increased tissue resistance to periodontal probing is regarded as a further indication for effective resolution of the periodontal inflammation and formation of a long junctional epithelium. Both treatment with the sonic scaler and with the curettes resulted in a significant PPD reduction of about 1 mm in moderate and of 2 mm in deep periodontal pockets as well as in a significant CAL gain of 1 mm in both pocket depth categories. Both treatment methods were similarly effective in PPD reduction and CAL gain. These results are in accordance with data reported in different recent meta-analyses (Tunkel et al. 2002, Van der Weijden & Timmerman 2002, Hallmon & Rees 2003). Beuchat et al. (2001) showed a greater PPD reduction in deep periodontal pockets with another sonic scaler (Periosonic: 2.4 mm *versus* S/RP: 3.0 mm). Loos et al. (1989) found a PPD reduction of 2.3 mm in their study. Using an ultrasonic scaler for subgingival debridement, Wennström et al. (2005) reported a mean PPD reduction of 1.6 mm in 5–6 mm-pockets and of 2.2 mm in deep pockets after 3 months (before re-instrumentation). A recent review on the effectiveness of subgingival debridement in general reported PPD reductions of 1.5–2.3 mm in deep periodontal pockets (Van der Weijden & Timmerman 2002). In agreement with previous studies (Beuchat et al. 2001, Kocher et al. 2001b, Wennström et al. 2005), in the present study deeper sites showed the greatest PPD reduction and the greatest gain in CAL.

Assuming the majority of periodontal pockets can be treated equally effectively with both sonic scaler and hand curettes, other aspects, like treatment time and unwanted side effects, become more important. In the present study, the operator was not given a time limit to allow an adequate and sufficient subgingival debridement of each tooth according to its individual needs. This was in accordance with previous studies (Torfason et al. 1979, Laurell & Pettersson 1988, Copulos et al. 1993, Yukna et al. 1997). In contrast, Wennström et al. (2005) allowed only 1 h for full-mouth ultrasonic treatment, while they set no time limit for the S/RP control procedure. In the present study, completion of root debridement was indicated by a smooth root surface free of bacterial plaque and calculus verified by a dental explorer and magnifying lenses. Although probing of the root surface may be an unreliable method to detect all residual bacterial deposits (Sherman et al. 1990), under clinical circumstances, this is the only possibility to verify an adequate subgingival debridement at the time of instrumentation. Within the limits of the present study design, treatment with the modified sonic scaler required less time than hand instrumentation (3.4 *versus* 6.1 min./tooth). The inclusion of only one operator makes the extrapolation of the treatment time to other operators difficult. However, the clear tendency of a reduced treatment time in favour of the sonic scaler is in accordance with a recent review (Tunkel et al. 2002) concluding that machine-driven instruments

save about 37% of treatment time compared with S/RP. Wennström et al. (2005) found that ultrasonic scaling of 2 min./tooth was equally effective as hand instrumentation of 6.5 min./tooth.

So far, there has been no report in the literature about possible side effects like post-operative hypersensitivity using sonic scalers compared with S/RP (AAP Position Paper 2000). In the present study, SonicFlex treatment did not cause post-operative hypersensitivity. However, similar to several previous studies (Chabansky et al. 1996, 1997, Tammaro & Wennström 2000, Troil et al. 2002), post-operative hypersensitivity was found 4 weeks after S/RP, while after 6 months no post-operative hypersensitivity was recorded. Given the difference in the treatment time in the present study, an overinstrumentation by the hand curettes cannot be excluded. The observed root hypersensitivity in S/RP sites after 4 weeks is an indication of unwanted tooth substance loss. Previous studies on the tooth substance removal favoured sonic or ultrasonic devices (Ritz et al. 1991, Schmidlin et al. 2001). In accordance with these findings and two other *in vitro* studies (Kocher et al. 2001a, Jepsen et al. 2004), our data indicated that the Sonicflex scaler with the round probe-shaped inserts caused less root substance loss, but was similarly effective in disrupting the biofilm and removing the calculus compared with hand instrumentation.

Conclusions

Within the limitations of this study:

1. The modified sonic scaler system and S/RP by hand curettes provided similarly favourable periodontal healing results.
2. In deep pockets, S/RP appeared to achieve better resolution of inflammation.
3. S/RP resulted in initially more hypersensitive teeth, possibly due to an overinstrumentation.
4. Instrumentation with the sonic scaler system seems to require significantly less time.

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Clinical Relevance

Scientific rationale: Periodontal healing requires an effective subgingival debridement of the bacterial biofilm and calculus with minimal loss of tooth substance. To evaluate the effectiveness of a modified sonic scaler, the clinical and microbiological healing outcomes were evaluated.

Principal findings: Compared with S/RP with hand curettes, the sonic scaler system provided similarly favourable clinical and microbiological healing results, although it showed a higher residual BOP score in deep ($\geqslant$7 mm) periodontal pockets after 6 months. In this study, it required less treatment time and caused less hypersensitivity.

Practical implications: The investigated modified sonic scaler system seems to be an acceptable alternative to S/RP for non-surgical subgingival debridement.