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Hand instrumentation *versus* ultrasonic debridement in the treatment of chronic periodontitis: a randomized clinical and microbiological trial

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Abstract

Aim: To compare the effectiveness of scaling and root planing (SRP) with the use of hand instruments to that of non-surgical treatment with the use of an ultrasonic device, using clinical and microbiological criteria.

Material and Methods: Thirty-three patients with chronic periodontitis participated in this randomized-controlled clinical trial divided into two groups. Patients in the control group received SRP with hand instruments, whereas patients in the test group received ultrasonic debridement (UD). Clinical recordings concerning probing pocket depth, clinical attachment level, plaque index and gingival bleeding index were performed at baseline, 3 and 6 months after baseline. Subgingival samples were analysed using the ''checkerboard'' DNA–DNA hybridization technique for *Porphyromonas gingivalis*, *Aggregatibacter actinomycetemcomitans, Tannerella forsythia* and *Treponema denticola*.

Results: Both treatments resulted in a significant improvement in all clinical recordings. Three months after treatment, a numerical decrease was observed for *P. gingivalis, T. forsythia and T. denticola* in both groups, which was statistically significant only for *P. gingivalis* ($p<0.05$). Inter-group differences were observed at 6 months for *T. forsythia* and *T. denticola* ($p<0.05$), favouring SRP.

Conclusions: Both treatment modalities provided comparable clinical results in the treatment of chronic periodontitis.

Key words: ''checkerboard'' DNA–DNA hybridization; chronic periodontitis; RCT; scaling and root planing; ultrasonic debridement

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Periodontal therapy consists of treatment modalities aimed at arresting infection and maintaining a healthy periodontium. The presence of one or more pathogenic species in sufficient numbers is necessary in the development of periodontitis. *Aggregatibacter actinomycetemcomitans*, *Porphyromonas gingivalis*, *Tannerella forsythia* and *Treponema denticola* are considered key pathogens in the initiation and progression of the disease. *P. gingivalis, T. forsythia* and *T. denticola*, which belong to the red complex according to Socransky et al. (1998), are strongly related to periodontal destruction. The periodic mechanical removal of subgingival microbial biofilms is essential for controlling inflammatory periodontal diseases, because disease-causing bacteria can repopulate pockets within weeks following active therapy (Sbordone et al. 1990).

In the past, the removal of hard deposits was primarily performed with

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hand instruments because sonic and ultrasonic scalers were originally designed for gross scaling and removal of supragingival calculus and stains (Johnson & Wilson 1957). Numerous studies have reported beneficial results from this treatment modality in both clinical and microbiological parameters (Lindhe et al. 1984, Badersten et al. 1987, Ramfjord et al. 1987, Renvert et al. 1990, Kaldahl et al. 1996, Takamatsu et al. 1999). However, such instrumentation calls for clinical skills and sometimes despite them, the anatomy of the root precludes the achievement of the desired biologically compatible root surface (Sherman et al. 1990). More recently, power-driven instruments have been modified to have smaller diameter tips and longer working lengths, thereby providing better access to deep pockets and more efficient subgingival instrumentation (Holbrook & Low 1994). In general, the evidence suggests that the disruption and removal of subgingival biofilms can be accomplished by power-driven scalers at a level comparable to manual scalers (Thornton & Garnick 1982, Leon & Vogel 1987, Oosterwaal et al. 1987, Renvert et al. 1990). A number of studies have reported on the comparative clinical outcome of sonic and ultrasonic *versus* manual instrumentation (Torfason et al. 1979, Badersten et al. 1981, 1984). To our knowledge, there are few studies comparing the clinical and microbiological results following quadrant-wise scaling and root planing (SRP) with the similar approach, using an ultrasonic device. Additionally, limited data exist on the effectiveness of ultrasonic debridement (UD) in multirooted teeth (Tunkel et al. 2002).

The aim of the present study was to compare the effectiveness of SRP with the use of hand instruments with that of non-surgical treatment with the use of an ultrasonic device, using clinical and microbiological criteria.

Material and Methods

The study was designed as a 6-month randomized, prospective, controlled clinical trial, according to the CONSORT criteria (Altman et al. 2001). The subjects were recruited from the Postgraduate Clinic of the Department of Preventive Dentistry, Periodontology and Implant Biology, School of Dentistry, Aristotle University of Thessaloniki, Greece, between September 2004 and March 2005. The Ethical Committee of the School of Dentistry of Aristotle University of Thessaloniki, Greece, approved the study protocol, and all participating patients signed an informed consent at the beginning of the study.

Determination of sample size

Clinical attachment level (CAL) was set as the primary outcome. Probing pocket depth (PPD), gingival bleeding index (GBI) and plaque index were considered to be the secondary outcomes. The estimation of the study sample was based on a subject-level analysis. A mean difference in the observed CAL between groups of 1 mm with a standard deviation of 1 mm would require 16 patients per group to detect a significant difference at the 5% level (two-tailed) with an 80% power (GraphPad StatMate™ v2.0, GraphPad Software Inc., San Diego, CA, USA). A difference of 1 mm between groups was chosen as it was considered clinically significant. The same difference for the calculation of the sample size was utilized by a considerable number of similar studies (Haffajee et al. 2007, Needleman et al. 2007, Del Peloso Ribeiro et al. 2008). In order to compensate for probable dropouts during the course of the study, we recruited 40 patients.

Patient sample

Forty adult patients with generalized advanced chronic periodontitis (Armitage 1999) were finally recruited for the study following a screening examination of 52 patients by one examiner (I. V.), which included full-mouth probing and a radiographic examination. The inclusion criteria used in the selection of the study subjects were: (i) adults between 18 and 70 years of age, (ii) existence of a minimum of four sites with PPD $\geqslant$5 mm in at least two quadrants of each of the patients, demonstrating bleeding on probing, and (iii) no periodontal treatment during the previous 6 months. The exclusion criteria were: (i) compromised medical condition, (ii) systemic antibiotics during treatment or for the last 3 months, (iii) ongoing drug therapy that might affect periodontal therapy, (iv) requirement for prophylactic antibiotic cover of the patient, (v) use of chlorhexidine mouthwash or any other antimicrobial agent and (vi) pregnancy for female patients.

The patients fulfilling the necessary prerequisites were randomly assigned to two groups of 20 patients each: Group A, control group (SRP with hand instruments-SRP); and Group B, experimental group (UD).

Randomization of the study

The 40 patients were randomly assigned to the two treatment groups using random tables. The randomization list was kept by one of the authors (A. K.) until the patients were eligible for the study. The clinicians (I. I., N. D. and K. P.) who performed the therapy were unaware of the treatment modality until the first session for each patient, when a sealed envelope with a card indicating the treatment was opened. At all time points, the outcomes of the research were assessed blind, that is, the examiner (I. V.) was unaware of the kind of treatment the patient was receiving. The analysis of the subgingival samples was performed by three of the authors (I. I., N. D. and K. P.) who were also unaware of the treatment that the patient had received (coded samples).

Clinical recordings

1. Plaque index (O'Leary et al. 1972): presence/absence of plaque scored by running a probe along the tooth surface.
2. GBI (Carter & Barnes 1974).
3. PPD: measured with a manual periodontal probe (Hu-Friedy PCP-UNC 15, Hu-Friedy, Chicago, IL, USA) to the nearest millimetre.
4. CAL: the distance between the cementoenamel junction of the tooth and the deepest aspect of the pocket, measured with a manual periodontal probe (Hu-Friedy PCP-UNC 15, Hu-Friedy).

Plaque index and GBI measurements were assessed at four surfaces per tooth (mesial, distal, buccal, lingual or palatal surface), while PPD and CAL measurements were taken at six surfaces per tooth (mesio-buccal, mid-buccal, disto-buccal and mesio-lingual, mid-lingual, disto-lingual or -palatal surface). For the measurement of PPD and CAL, the periodontal probe was placed parallel to the long axis of the tooth. The probing force was not standardized.

The same examiner (I. V.) performed all clinical recordings and microbiologi-

cal sampling. The intraexaminer variability test was carried out to assess the accuracy of the measurements within the examiner. In order to assure the reproducibility of the measurements, all recordings regarding PPD and CAL were repeated after a period of 30 min. In the event of a difference of >2 mm between the two measurements, a third measurement was performed at the respective site. The mean of the pair of the two closer measurements was evaluated for further analysis.

Experimental design

At the screening examination, full-mouth measurements of clinical parameters were recorded and intraoral radiographs were taken. After a period of 1 week (baseline examination), subgingival plaque samples were taken from six preselected sites from each patient. The sites were selected according to their initial probing depth and were divided into three categories: (i) two sites with PPD $\leqslant 4$ mm (shallow pockets), (ii) two sites with $4<$PPD $\leqslant 6$ mm (moderate pockets) and (iii) two sites with PPD >6 mm (deep pockets). No furcation, endo-periodontic defects or third molars were included in the study material. In the same session, supragingival scaling was performed with hand instruments and ultrasonics, and oral hygiene instructions (OHI) were given by the examiner. The OHI included twice-daily tooth brushing using the modified Bass technique and once-daily inter-dental cleaning with inter-dental brushes. At the next appointment, 2 weeks after the baseline examination, the allocated intervention was initiated.

Microbiological sampling at the same sites as those at the baseline examination and full-mouth clinical recordings was repeated at 3 and 6 months after baseline.

Treatment procedures

The patients participating in the control group received quadrant-wise SRP treatment of the whole dentition, under local anaesthesia, at weekly intervals, in three to four sessions. An assortment of manual periodontal curettes was used (Hu-Friedy Gracey Standard Curettes SG 3/4, 11/12, 13/14, After Five® Curettes SAS 3/4, 11/12, 13/14, Hu-Friedy). The curettes were sharpened at the operator's request. The root instrumentation was completed when a smooth, hard surface was achieved. The smoothness of the root surface was checked using a periodontal probe (Hu-Friedy PCP 11, Hu-Friedy) and an explorer (Hu-Friedy Wilkins-Tufts 17/23, Hu-Friedy).

The patients of the experimental group received treatment, which comprised of debridement of the whole dentition in three to four sessions, under local anaesthesia, at weekly intervals, using a piezoelectric ultrasonic device (EMS Piezon®, EMS, Nyon, Switzerland) with A and P instruments (Swiss Instruments^{PM}, EMS) under water irrigation. The tips were examined after every session and were discarded when they had worn out. The teeth were treated until a smooth, appropriately debrided surface was achieved. The same instruments as above were used to ensure the proper debridement of the root surface. The endpoint of the smoothness was judged by the supervisor (I. V.), who decided upon the completion of the root instrumentation.

No restrictions in instrumentation time were set in any group; however, hand instrumentation seemed to require more time. Supragingival scaling was repeated on every patient at the recall sessions and the patients were reinforced in oral hygiene measures.

Microbiological evaluation

After isolation with cotton rolls, drying and removal of supragingival plaque, subgingival samples were taken with a sterile Gracey curette (Hu-Friedy), subsequently placed individually in 200 μl of TE buffer (Tris HCl 10 mM, EDTA 1 mM, pH = 7.5) and stored after treatment with an alkali solution (0.5 M NaOH) at -4°C.

The microbiological samples were evaluated separately for four bacterial species using the ''checkerboard'' DNA–DNA hybridization technique as described by Socransky et al. (1994). The subgingival species used for development of digoxigenin-labelled whole genomic probes were *P. gingivalis* (FDC 381), *A. actinomycetemcomitans* serotype b (FDC Y4), *T. forsythia* (FDC 338) and *T. denticola* (TD1).

Data analysis

The data were analysed using the patient as a unit. The primary analysis was ''per protocol'' (Altman et al. 2001) and included all patients who attended the final examination. Data were entered into an Excel sheet database (MS Office Excel 2000; Microsoft Corporation, Redmond, WA, USA). The mean and standard error of mean were calculated for every parameter. Levene's test for quality of error variance was applied in order to check the homogeneity of clinical parameters at the baseline. The analysis was performed for plaque index, GBI, PPD and CAL based on full-mouth measurements (third molars were not included). A further analysis was performed for PPD and CAL for three different categories, according to the initial pocket depth. The first category comprised pockets with initial pocket depth $\leqslant 4$ mm, the second pockets with initial pocket depth $4<$PPD $\leqslant 6$ mm and the third pockets with pocket depth >6 mm.

Bacterial species were quantified following the formation of a reference curve, which allowed the conversion of the chemiluscent signals to total bacterial counts (Total Lab™ v2005, Nonlinear Dynamics Ltd., Newcastle upon Tyne, UK). The homogeneity of the two groups at the baseline for microbiological parameters was checked with the Mann–Whitney test. Averaged bacterial scores from each subject were averaged for each group and compared at all time points. A further comparison at the three examinations was made for sites with initial PPD >4 mm (moderate and deep pockets), which are the most important in clinical practice.

The differences over time within groups for both clinical and microbiological results were analysed with the non-parametric Wilcoxon's Signed Ranks test. The comparison between the control and the test group was performed with the Mann–Whitney test. Analysis of covariance (ANCOVA) was performed for multiple comparisons, which was corrected with the Bonferroni test whenever necessary. The level of significance was set at $p<0.05$. All statistical analysis was carried out with the aid of statistical software (SPSS version 12.0, SPSS Inc., Chicago, IL, USA).

Results

At the baseline examination, 40 patients entered the study (20 in the SRP group, 20 in the UD group), from which 33 subjects completed the 6-month protocol (16 in the SRP group, 17 in the UD group, mean age 50.06, range 33–68 years). One patient in the experimental

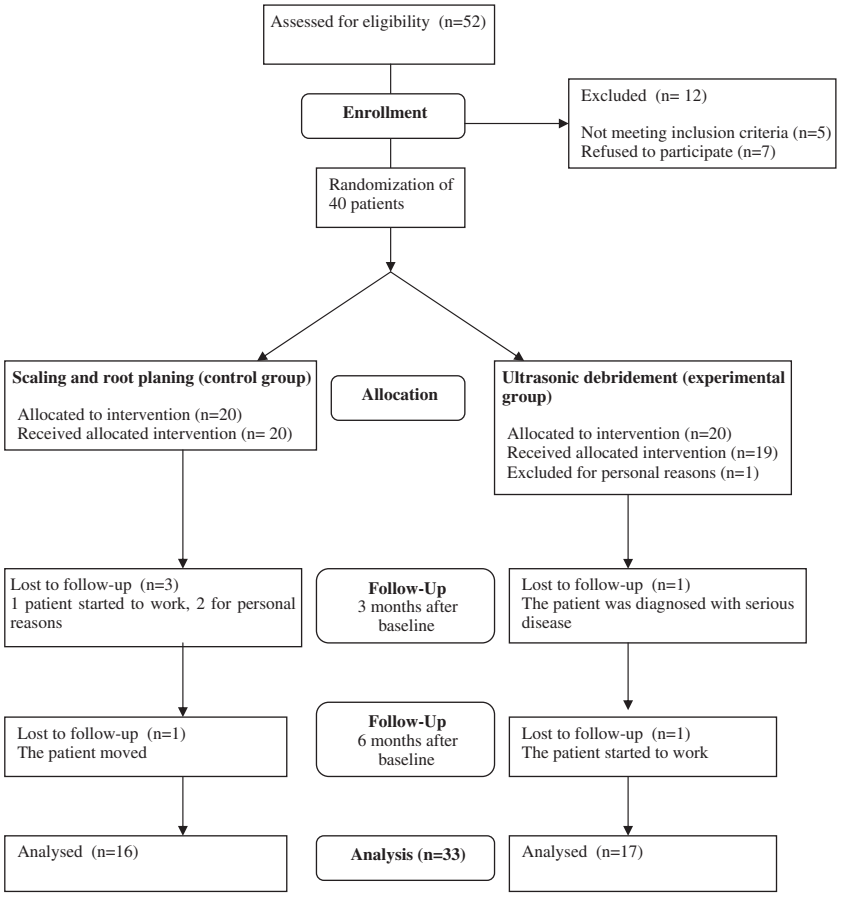

Fig. 1. Flowchart of the patients throughout the study.

Table 1. Epidemiological characteristics of the patient sample (mean ± SEM, per protocol analysis)

	SRP	UD
N	16	17
Age (years)	49.62 ± 2.07	50.47 ± 2.58
Gender (male/female%)	50/50	29.4/70.6
Smokers	50%	52.9%
Initial PPD (mm)	3.91 ± 0.21	3.49 ± 0.16
Initial CAL (mm)	5.37 ± 0.42	4.49 ± 0.30

SRP, scaling and root planing; UD, ultrasonic debridement; PPD, probing pocket depth; CAL, clinical attachment level.

group did not receive the allocated intervention due to personal reasons. Four patients did not return for any re-examination, while another two did not attend the final examination. One patient moved, two patients started to work and could not visit our clinic, one was diagnosed with a serious disease and the other two were not willing to finish the study because of personal reasons. The flowchart of the patients is illustrated in Fig. 1, and the characteristics of the patient sample that completed the study are summarized in Table 1. The initial statistical analysis revealed no statistical differences between the two groups at the baseline examination. The intraexaminer variability test demonstrated that the reproducibility of the measurements of PPD and CAL within ± 1 mm was 90%.

An average of 69.1% of all pockets in the SRP group and 71.9% in the UD group had initially PPD ⩽ 4 mm. The moderate pockets comprised 23% and 21.4% of all pockets, respectively. The deep pockets were 7.9% and 6.7%, respectively. At the 6-month examination in the SRP group, the shallow pockets represented 84.9%, the moderate pockets 11.3% and the deep pockets only 3.8% of all pockets. In the UD group, the corresponding percentages were 85.4%, 11.9% and 2.7%.

Plaque index

The oral hygiene status, as assessed by the plaque index, during the course of the study is shown in Table 2. At baseline, the mean full-mouth plaque scores were 88% in the SRP group and 84% in the UD group. A remarkable decrease in these scores was observed for both groups at the 3-month examination, which was statistically significant (Wilcoxon's Signed Ranks test, $p < 0.05$). The results were maintained until the final examination. The plaque index presented a more significant reduction in the SRP group, which did not affect the results in the other parameters examined (ANCOVA, $p > 0.05$, data not shown).

GBI

A statistically significant reduction in GBI scores was observed in both treatment groups, following treatment. Hence, at the 3-month re-examination the GBI was reduced from 59% to 32% in the SRP group and from 52% to 24% in the UD group (Wilcoxon's Signed Ranks test, $p < 0.05$, Table 2). The results were maintained throughout the study. There was no statistically significant difference in GBI between the two groups at any examination interval (Mann–Whitney test, $p > 0.05$).

PPD Measurements

In total, the probing assessments revealed a statistically significant mean PPD reduction of 0.88 and 0.53 mm for the SRP and the UD group, respectively, at the 3-month re-examination (Wilcoxon's Signed Ranks test, $p < 0.05$, Table 3). Changes in PPD from the 3- to the 6-month examination were very small. No statistically significant differences were observed between the two groups at any interval (Mann–Whitney test, $p > 0.05$).

The PPD measurements were further analysed for the three different categories of initial pocket depth. For the shallow (PPD ⩽ 4 mm), the moderate (4 < PPD ⩽ 6 mm) and the deep pockets (PPD > 6 mm), the results are presented in Table 3.

Table 2. Mean plaque index and GBI scores (mean ± SEM) at various examination intervals

	Baseline	3 months	6 months
Plaque index			
SRP	0.88 ± 0.03	0.26 ± 0.06*	0.26 ± 0.05*
UD	0.84 ± 0.05	0.45 ± 0.07*,†	0.49 ± 0.06*,†
GBI			
SRP	0.59 ± 0.05	0.32 ± 0.04*	0.33 ± 0.05*
UD	0.52 ± 0.04	0.24 ± 0.03*	0.33 ± 0.05*

*Statistically significant difference from baseline (Wilcoxon's Signed Ranks test, $p<0.05$).
†Statistically significant difference between groups (Mann–Whitney test, $p<0.05$).
SRP, scaling and root planing; UD, ultrasonic debridement. GBI, gingival bleeding index.

Table 3. Mean PPD scores (mean ± SEM) for the various PPD categories, according to initial PPD

PPD	Baseline (mm)	3 months (mm)	6 months (mm)
⩽4 mm			
SRP	2.90 ± 0.10	2.50 ± 0.08*	2.57 ± 0.14*
UD	2.74 ± 0.10	2.49 ± 0.10*	2.63 ± 0.12#
4<PPD⩽6 mm			
SRP	5.39 ± 0.05	3.84 ± 0.11*	3.86 ± 0.20*
UD	5.32 ± 0.03	4.09 ± 0.13*	4.04 ± 0.16*
>6			
SRP	7.88 ± 0.23	5.17 ± 0.20*	4.74 ± 0.31*
UD	7.49 ± 0.11	5.33 ± 0.19*	5.21 ± 0.33*
Overall			
SRP	3.91 ± 0.21	3.03 ± 0.13*	3.03 ± 0.19*
UD	3.49 ± 0.16	2.96 ± 0.12*	3.05 ± 0.14*

*Statistically significant difference from baseline (Wilcoxon's Signed Ranks test, $p<0.05$).
#Statistically significant difference from 3 months (Wilcoxon's Signed Ranks test, $p<0.05$).
No statistically significant differences were observed between groups (Mann–Whitney test, $p>0.05$).
SRP, scaling and root planing; UD, ultrasonic debridement; PPD, probing pocket depth.

Table 4. Mean CAL scores (mean ± SEM) for the various PPD categories, according to initial PPD

CAL	Baseline (mm)	3 months (mm)	6 months (mm)
⩽4 mm			
SRP	4.45 ± 0.35	4.41 ± 0.35	4.36 ± 0.36
UD	3.77 ± 0.28	3.76 ± 0.26	3.89 ± 0.22
4<PPD⩽6 mm			
SRP	6.93 ± 0.26	5.68 ± 0.32*	5.68 ± 0.34*
UD	6.18 ± 0.22	5.39 ± 0.26*	5.43 ± 0.22*
>6			
SRP	9.10 ± 0.32	7.04 ± 0.32*	6.55 ± 0.44*
UD	8.45 ± 0.20	6.56 ± 0.30*	6.49 ± 0.35*
Overall			
SRP	5.37 ± 0.42	4.87 ± 0.37*	4.78 ± 0.40*
UD	4.49 ± 0.30	4.23 ± 0.26*	4.32 ± 0.21

*Statistically significant difference from baseline (Wilcoxon's Signed Ranks test, $p<0.05$).
No statistically significant differences were observed between groups (Mann–Whitney test, $p>0.05$).
SRP, scaling and root planing; UD, ultrasonic debridement; PPD, probing pocket depth; CAL, clinical attachment level.

CAL Measurements

At the 3-month re-examination, the measurements revealed a statistically significant mean CAL gain of 0.50 mm for the SRP group and 0.26 mm for the UD group, respectively (Wilcoxon's Signed Ranks test, $p<0.05$, Table 4). The results were maintained for both groups at the 6-month examination. No statistically significant differences were observed between the two groups at any interval (Mann–Whitney test, $p>0.05$). In the SRP group, the result remained significantly better compared with the baseline score (Wilcoxon's Signed Ranks test, $p<0.05$), whereas in the UD group the mean CAL score was not significantly different from the baseline value (Wilcoxon's Signed Ranks test, $p>0.05$).

A similar analysis as for the PPD measurements was performed for the CAL measurements as well. The results for the shallow, moderate and deep pockets are shown in Table 4. For the shallow pockets, no statistically significant inter- (Mann–Whitney test, $p>0.05$) or intra-group (Wilcoxon's Signed Ranks test, $p>0.05$) differences were observed. The moderate pockets gained 1.25 mm in the SRP group and 0.75 mm in the UD group at the 6-month re-examination. For the deep pockets, the corresponding mean CAL gain was 2.55 and 1.96 mm, respectively. The differences between 3- and 6-month re-examinations and the baseline examination were statistically significant for the two groups (Wilcoxon's Signed Ranks test, $p<0.05$). No statistically significant differences were found between the two groups at any time interval (Mann–Whitney test, $p>0.05$).

Multirooted teeth

This subpopulation comprised of 174 teeth in 33 patients. Each patient contributed one to eight teeth in this analysis. The mean PPD and CAL scores were reduced significantly in the SRP group by 0.73 and 0.76 mm, respectively, at the final examination (Wilcoxon's Signed Ranks test, $p<0.05$, Table 5). In the UD group, the PPD score was reduced by 0.24 mm, which was not statistically significant (Wilcoxon's Signed Ranks test, $p<0.05$). For CAL assessments, the difference was only slight and statistically insignificant (Wilcoxon's Signed Ranks test, $p>0.05$). No statistically significant differences were found between the two groups at any time interval (Mann–Whitney test, $p>0.05$).

Microbiological parameters

In total, 594 microbiological samples were analysed. The results for all investigated species are summarized in

Table 6, for all six sites per patient. At the 3-month examination, a numerical decrease was observed for all species, except for *A. actinomycetemcomitans*. This decrease was statistically significant only for *P. gingivalis* (Wilcoxon's Signed Ranks test, $p<0.05$). Between the 3- and the 6-month re-examination, a statistically significant increase in the number of *T. forsythia* was found in the experimental group (Wilcoxon's Signed Ranks test, $p<0.05$). An inter-group statistically significant difference was found in the 6-month re-examination for *T. forsythia* and *T. denticola* (Mann–Whitney test, $p<0.05$), in favour of SRP. This difference can be mainly attributed into an increase in the number of these species in the deeper pockets (initial PPD > 4 mm) in the experimental group.

The frequency distribution revealed an increase in the percentage of sites with $\leqslant 10^5$ microorganisms for *P. gingivalis, T. forsythia* and *T. denticola* and a subsequent decrease in the percentage of sites with more than 10^5 microorganisms (Table 7).

The results of a further analysis that was performed for sites, which had initial PPD > 4 mm, are presented in Table 6. A statistically significant decrease was found for *P. gingivalis* in both groups at the 3-month examination (Wilcoxon's Signed Ranks test, $p<0.05$). At the same time point, a statistically significant decrease was also found for *T. forsythia* in the experimental group (Wilcoxon's Signed Ranks test, $p<0.05$). From 3 to 6 months, a statistically significant increase in the presence of the same species was found (Wilcoxon's Signed Ranks test, $p<0.05$). The only inter-group difference was observed at the 6-month examination for *T. denticola* (Mann–Whitney test, $p<0.05$).

Table 5. Mean PPD and CAL scores (mean ± SEM) for multirooted teeth

Multirooted teeth	Baseline (mm)	3 months (mm)	6 months (mm)
PPD			
SRP	4.58 ± 0.19	3.69 ± 0.16*	3.85 ± 0.23*
UD	4.18 ± 0.15	3.92 ± 0.27*	3.94 ± 0.27
CAL			
SRP	6.42 ± 0.39	5.67 ± 0.39*	5.66 ± 0.37*
UD	5.35 ± 0.28	5.22 ± 0.29	5.34 ± 0.30

*Statistically significant difference from baseline (Wilcoxon's Signed Ranks test, $p<0.05$).
No statistically significant differences were observed between groups (Mann–Whitney test, $p>0.05$).
SRP, scaling and root planing; UD, ultrasonic debridement; PPD, probing pocket depth; CAL, clinical attachment level.

Table 6. Mean numbers (x10^5, mean ± SEM) of the four species tested at different examination intervals

	Baseline	3 months	6 months	Baseline	3 months	6 months
	overall			initial PPD > 4 mm		
Pg						
SRP	7.36 ± 2.29	2.63 ± 0.72*	1.39 ± 0.44*	7.97 ± 0.24	3.04 ± 0.98*	1.68 ± 0.57
UD	5.45 ± 0.99	2.76 ± 0.69*	2.45 ± 0.59*	6.90 ± 1.35	3.00 ± 0.73*	2.76 ± 0.63*
Aa						
SRP	1.51 ± 0.43	2.21 ± 0.53	0.99 ± 0.19	1.48 ± 0.53	2.13 ± 0.57	0.97 ± 0.19
UD	1.74 ± 0.69	1.94 ± 0.71	1.66 ± 0.49	1.81 ± 0.64	1.80 ± 0.64	1.84 ± 0.59
Tf						
SRP	4.20 ± 1.57	0.75 ± 0.28	0.83 ± 0.24	4.39 ± 1.64	0.95 ± 0.42	1.01 ± 0.27
UD	3.06 ± 0.73	1.29 ± 0.49	2.44 ± 0.61#,†	3.59 ± 0.36	1.29 ± 0.45*	2.47 ± 0.59#
Td						
SRP	3.03 ± 1.54	0.88 ± 0.23	0.74 ± 0.38	2.86 ± 1.48	0.99 ± 0.34	1.01 ± 0.56
UD	2.64 ± 0.73	1.05 ± 0.41	3.18 ± 1.21†	3.41 ± 0.93	1.24 ± 0.44	3.86 ± 1.47†

Pg, *Porphyromonas gingivalis*; *Aa*, *Aggregatibacter actinomycetemcomitans*; *Tf*, *Tannerella forsythia*; *Td*, *Treponema denticola*.
*Statistically significant difference from baseline (Wilcoxon's Signed Ranks test, $p<0.05$).
#Statistically significant difference from 3 months (Wilcoxon's Signed Ranks test, $p<0.05$).
†Statistically significant difference between groups (Mann–Whitney test, $p<0.05$).
SRP, scaling and root planing; UD, ultrasonic debridement; PPD, probing pocket depth.

Table 7. Frequency distribution of the four species tested at different examination intervals

	Baseline	3 months	6 months	Baseline	3 months	6 months
	$\leqslant 10^5$			$> 10^5$		
Pg						
SRP	58,3%	74.4%	85.4%	41,7%	25.6%	14.6%
UD	47,1%	72.5%	77.5%	52,9%	27.5%	22.5%
Aa						
SRP	74.4%	70.0%	80.6%	25.6%	30%	19.4%
UD	70.8%	78.1%	76.4%	29.2%	21.9%	23.6%
Tf						
SRP	61,1%	87,5%	81,0%	38,9%	12,5%	19,0%
UD	64,7%	82,4%	66,7%	35,3%	17,6%	33,3%
Td						
SRP	73,3%	89,5%	94,0%	26,7%	10,5%	6,0%
UD	71,6%	78,4%	71,6%	28,4%	21,6%	28,4%

Pg, *Porphyromonas gingivalis*; *Aa*, *Aggregatibacter actinomycetemcomitans*; *Tf*, *Tannerella forsythia*; *Td*, *Treponema denticola*.
SRP, scaling and root planing; UD, ultrasonic debridement.

Discussion

The findings of the present study indicate that the use of a piezoelectric device results in a treatment outcome comparable with that of SRP with hand instruments 6 months after non-surgical periodontal therapy. The short-term findings of this study are in accordance with other trials comparing the effect of both approaches in the non-surgical mechanical treatment of the root surface. Early (Torfason et al. 1979, Badersten et al. 1981, 1984, Oosterwaal et al. 1987) as well as more recent studies (Dragoo 1992, Copulos et al. 1993, Obeid et al. 2004, Koshy et al. 2005, Christgau et al. 2007, Derdilopoulou et al. 2007, Del Peloso Ribeiro et al. 2008) have shown that root surface

debridement with either hand curettes or ultrasonic devices leads to similar clinical and microbiological improvement of periodontal conditions. Hence, within the limitations of the present study, taking into consideration the detailed experimental design based on randomization, operator's blindness and stringent follow-up of the participants, the findings of the current trial support the use of ultrasonic devices in the treatment of chronic periodontitis.

A marked reduction in every clinical parameter was observed for both groups in this study. Overall, a statistically significant mean reduction in PPD of 0.88 mm and a mean CAL gain of 0.59 mm were found for the SRP group, whereas for the UD group the respective numbers were 0.44 and 0.17 mm. The improvement was more pronounced for the moderate and the deep pockets. At the 6-month re-examination, the CAL measurement for the UD group did not differ significantly from the baseline examination, implying a more stable result in the control group. These results are in accordance with numerous studies, which used a comparable methodology (Torfason et al. 1979, Badersten et al. 1981, 1984, Dragoo 1992, Copulos et al. 1993, Obeid et al. 2004). In these studies, the PPD reduction ranged from 0.75 to 1.07 mm for the SRP group and from 0.72 to 1 mm for the UD group. For the CAL, the results for the SRP ranged from -0.10 to 0.28 mm and for the UD from -0.20 to 0.30 mm.

Statistically significant differences between the two groups were not found, except for the plaque index. This finding did not seem to affect the other parameters, as was proved by the statistical analysis. One possible explanation is that following the use of hand instruments, a better environment for oral hygiene measures was established, as a result of the tissue shrinkage. In addition to this, due to the fact that the hand instrumentation of the root surface was more time consuming, the patients in the SRP group were motivated for improved self-performed oral hygiene.

The issues of correctly measuring supragingival plaque in clinical trials, the inability of current plaque indices to assess subgingival accumulations and even the effect of personal hygiene on chronic periodontitis remain unresolved (Goodson 1986, Lindhe et al. 1986, Hujoel et al. 2005). In the present study, we included microbiological assessments, obtaining information about the subgingival plaque of the sites under investigation and the impact of therapy on consensus periodontal pathogens.

Based on the clinical treatment outcome, two recent systematic reviews (Tunkel et al. 2002, Hallmon & Rees 2003) concluded that there is a comparable effectiveness between manual and power-driven root instrumentation when treating single-rooted teeth with chronic periodontitis. For multirooted teeth, on the other hand, there is no evidence on the effectiveness of power-driven instruments (Tunkel et al. 2002). However, power-driven instrumentation has been shown to be superior in the treatment of Classes II and III furcations when used by experienced operators (Leon & Vogel 1987). In our study, in spite of an initially comparable improvement in PPD between SRP and UD, the results in the control group seemed to be more stable. For CAL assessments, only SRP seems to have a significant effect on multirooted teeth.

At the 3-month re-examination, both therapeutic approaches resulted in a statistically significant reduction of the number of *P. gingivalis* only. A profound, yet not statistically significant, reduction was observed for *T. forsythia* and *T. denticola* as well, but in no case was eradication of the periopathogenic species found. No mechanical therapy seems to have an effect in the presence of *A. actinomycetemcomitans*. This may be explained by the characteristic of *A. actinomycetemcomitans* to penetrate into the soft tissues, and implies requirement of the use of antimicrobial agents in order to reduce the numbers of this species. This inability of mechanical therapy to eliminate *A. actinomycetemcomitans* is in accordance with other studies, which evaluated the effect of non-surgical therapy on key periodontal pathogens (Renvert et al. 1990, Takamatsu et al. 1999, Christgau et al. 2007, Derdilopoulou et al. 2007, Del Peloso Ribeiro et al. 2008). Statistically significant differences between groups were observed only for *T. forsythia* and *T. denticola* for the whole sample and for *T. denticola* in the initially deeper pockets (initial PPD >4 mm) at the 6-month re-examination in favour of SRP. Nevertheless, it cannot be ruled out that the observed difference in plaque scores could have led to faster recolonization and reinfection of the tested sites and, as a result, it may have affected the microbiological findings.

In the present study, we used a quadrant-wise treatment modality in both groups with either hand instruments or ultrasonics to compare their effectiveness in the treatment of chronic periodontitis. The recolonization of the treated sites with bacteria from untreated quadrants or other intra-oral niches remains an unresolved problem. As recent data suggest (Koshy et al. 2005, Jervøe-Storm et al. 2007a, Del Peloso Ribeiro et al. 2008), there is no difference in microbiological outcomes between a quadrant-wise and a full-mouth treatment approach in spite of the initial, favourable results for full-mouth disinfection (Quirynen et al. 1999, 2000).

In a split-mouth study, hand and ultrasonic instrumentation resulted in a reduction of spirochetes and motile rods, with concomitant increases in cocoid cells throughout the experimental period of 49 days (Oosterwaal et al. 1987). Both treatments reduced the total CFUs and the number of black-pigmented *Bacteroides* and *Capnocytophaga* (Oosterwaal et al. 1987). Quadrant-wise UD resulted in slight and insignificant changes in the detection frequency of most of the periodontal pathogens in plaque as detected by PCR (Koshy et al. 2005). The effects of the treatment were more noticeable on levels of *T. denticola* (Koshy et al. 2005). Copulos et al. (1993) compared the manual curette with a modified ultrasonic insert, designed to provide better access to difficult root surface areas, and reported equal reductions in microbial populations from 14 to 180 days post-treatment. Recently, ultrasonic root debridement was shown to leave fewer bacteria along treated surfaces than hand instrumentation alone, and so there may be additional advantages to using ultrasonic devices in conjuction with hand scalers for removing bacterial plaque (Crespi et al. 2005). In a split-mouth study of four different treatment modalities, the use of hand instruments and ultrasonics led to comparable reduction of the evaluated periodontal pathogens 3 months after treatment, whereas in 6 months the amount of bacteria increased again to a varying extent in each treatment group and for each species (Derdilopoulou et al. 2007). Accordingly, in a split-mouth study that compared periodontal healing outcome following the use of hand curettes *versus* a modified sonic scaler, the microbiological findings corroborated ours, namely

a slight increase was observed at the 6-month examination for *T. denticola* in the test sites and *T. forsythia* in both the test and the control sites (Christgau et al. 2006). In a similar study comparing a new piezoelectric ultrasonic system (Vector™) with hand instrumentation, no statistically significant differences were observed in microbiological parameters (Christgau et al. 2007).

The sampling technique is an important issue in microbiological testing. The most commonly used methods are those, that introduce the use of either a periodontal curette or a paper point. Recently, it was concluded that both techniques seem suitable for microbiological diagnostics, although higher amounts of subgingival bacteria were collected with curettes (Jervøe-Storm et al. 2007b). Teles et al. (2008), after receiving seven successive curette samples from both healthy and periodontally compromised sites, stated that the use of curettes provides a reliable and reproducible method to obtain subgingival samples.

The ultimate goal of instrumentation of pathological periodontal pockets is to render the root free from microbial deposits and calculus (Waerhaug 1978, Badersten et al. 1981, Lindhe et al. 1984). However, complete removal of microbial biofilms and calculus is not attainable, regardless of the type of instrument used (Thornton & Garnick 1982, Breininger et al. 1987, Garnick & Dent 1989). A consideration in relation to periodontal treatment is the extent of root instrumentation required for periodontal healing. Nowadays, the trend in therapeutic methodology in periodontology is the minimally aggressive approach in both surgical and non-surgical treatment. The old concept of extensive cementum removal in order to provide a root surface biocompatible for soft tissue healing (Hatfield & Baumhammers 1971, Aleo et al. 1974) has been questioned by various experimental studies (Nakib et al. 1982, Hughes & Smales 1986, Moore et al. 1986). In this respect, the utilization of sonic and ultrasonic devices for periodontal debridement offers a less aggressive and a more comfortable therapeutic method for both the patient and the therapist.

Recent data from studies evaluating root substance removal following the use of various manual and power-driven instruments (Busslinger et al. 2001, Schmidlin et al. 2001, Braun et al. 2005a, Crespi et al. 2005) favour the use of ultrasonic devices, while hand curettes seem more efficient in calculus removal in vitro (Braun et al. 2005b) and in vivo (Braun et al. 2006). On the other hand, Crespi et al. (2005) also showed that root surfaces treated with the ultrasonic instrument have a scaly and rough topography with some gouges in several areas, whereas teeth treated with curettes present smooth root surfaces, especially on convex surfaces. Cementum removal was more pronounced and a constant finding in teeth treated with hand instruments (Crespi et al. 2005). However, other reports found no obvious differences between manual and ultrasonic instrumentation in weight loss of the tested teeth (Obeid & Bercy 2005). An additional advantage of ultrasonic devices is reported in some studies that demonstrated much better access to the base of the pocket and calculus removal using micro-ultrasonic tips than hand instruments, particularly when probing depths exceed 6 mm (Dragoo 1992, Barendregt et al. 2008).

In conclusion, the findings of the present study indicate that the use of an ultrasonic device in the treatment of chronic periodontal disease leads to comparable results with the traditional approach of SRP carried out with hand instruments, considering both clinical and microbiological parameters. These results, though, should be interpreted with caution, as the microbiological findings at 6 months seem to favour SRP. Consequently, it is suggested that more long-term studies evaluating the healing outcome after both treatment modalities are needed, in order to draw definitive conclusions about the stability of each therapeutic approach.

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Clinical Relevance

Scientific rationale for the study: Few studies compare the clinical and microbiological results following quadrant-wise SRP with a similar approach using an ultrasonic device. Additionally, limited data exist on the effectiveness of UD on multirooted teeth.

Principal findings: Periodontal therapy with the use of an ultrasonic device resulted in clinical and microbiological improvement comparable with that of SRP. With respect to multirooted teeth, no statistically significant differences were also observed between groups.

Practical implications: Ultrasonic debridement provides clinical results comparable to hand instrumentation in the treatment of chronic periodontitis.