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Non-surgical periodontal treatment with a new ultrasonic device (Vector™-ultrasonic system) or hand instruments

A prospective, controlled clinical study

Anton Sculean[1], Frank Schwarz[2], Mohammad Berakdar[1], Georg E. Romanos[3], Michel Brecx[1], Britta Willershausen[1] and Jürgen Becker[1]

[1]Department of Periodontology and Operative Dentistry, Johannes Gutenberg-University, Mainz, Germany; [2]Department of Oral Surgery, Heinrich Heine University, Düsseldorf, Germany; [3]Department of Oral Surgery and Implantology, University of Frankfurt, Frankfurt, Germany

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Abstract

Objectives: The aim of this prospective, randomized, controlled clinical study was to compare the effectiveness of a newly developed ultrasonic device to that of scaling and root planing for non-surgical periodontal treatment.

Material and Methods: Thirty-eight patients with moderate to advanced chronic periodontal disease were treated according to an ''one-stage procedure'' with either a newly developed ultrasonic device (VUS) (Vector™-ultrasonic system) or scaling and root planing (SRP) using hand instruments. Clinical assessments by plaque index (PlI), gingival index (GI), bleeding on probing (BOP), probing depth (PD), gingival recession (GR), and clinical attachment level (CAL) were made prior to and at 6 months after treatment. Differences in clinical parameters were analyzed using the Wilcoxon signed ranks test and Mann and Whitney *U*-test.

Results: No differences in any of the investigated parameters were observed at baseline between the two groups. The mean value of BOP decreased in the VUS group from 32% at baseline to 20% after 6 months ($p < 0.001$) and in the SRP group from 30% at baseline to 18% after 6 months ($p < 0.001$).The results have shown that at moderately deep sites (initial PD 4–5 mm) mean CAL changed in the test group from 4.6 ± 1.2 to 4.2 ± 1.6 mm ($p < 0.001$) and in the control group from 4.8 ± 1.3 to 4.4 ± 1.5 mm ($p < 0.001$). At deep sites (inital PD > 6 mm) mean CAL changed in the test group from 8.5 ± 1.9 to 7.9 ± 2.4 mm ($p < 0.001$) and in the control group from 7.9 ± 1.6 to 7.2 ± 2.2 mm ($p < 0.001$). No statistically significant differences in any of the investigated parameters were found between the two groups.

Conclusion: Non-surgical periodontal therapy with the tested ultrasonic device may lead to clinical improvements comparable to those obtained with conventional hand instruments.

Key words: non-surgical periodontal treatment; periodontal disease; scaling and root planing; ultrasonic device/therapeutic use

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Periodontitis is an inflammatory disease caused by opportunistic bacteria residing in the oral cavity, leading to a loss of the supporting tissues of the teeth (i.e. periodontal ligament and alveolar bone) (O'Leary 1986). A major objective of periodontal therapy is to remove soft and hard supra- and subgingival deposits from the root surface in order to stop disease progression (O'Leary 1986). The most commonly used procedure for root surface debridement is mechanical scaling and root planing using hand instruments, e.g. Gracey curettes. Numerous studies have reported beneficial results from this treatment modality in both clinical and microbial parameters (Lindhe et al. 1984, Badersten et al. 1987, Ramfjord et al. 1987, Kaldahl et al. 1993, 1996, Serino et al. 2001). However, such

instrumentation calls for clinical skills and sometimes despite them, the anatomy of the root often precludes the achievement of the desired biologically compatible root surface (Sherman et al. 1990a, b). In order to mechanize the procedure of scaling and root planing, power-driven instruments, such as sonic and ultrasonic scalers have been proposed. Numerous studies have reported on the comparative clinical outcome of sonic and ultrasonic versus manual instrumentation (Torfason et al. 1979, Badersten et al. 1981, 1984, Loos et al. 1987). However, power-driven instruments have been shown to be superior in the treatment of Class II and Class III furcations when used by experienced operators (Leon & Vogel 1987). Furthermore, several studies reported on an increased efficiency of subgingival instrumentation with both sonic and ultrasonic scalers, since manual instrumentation generally takes longer to achieve the same clinical results (Dragoo 1992, Copulos et al. 1993).

Although periodontal treatment with power-driven instruments offers indeed some interesting perspectives to the clinician, some questions still remain and need to be solved. One of them is a considerable heat development at the scaler's tip when water cooling is not efficient. This increase in temperature may cause injury to pulpal and periodontal tissues (Nicoll & Peters 1998). Another drawback of power-driven instruments is the formation of pathogenic bacterial aerosols (Holbrook et al. 1978) and the reduced tactile sensation in comparison to hand instruments (Meyer & Lie 1977). Recently, a newly developed ultrasonic system (VUS) (Vector™-ultrasonic system, Dürr Dental, Bietigheim-Bissingen, Germany), generating vibrations at a frequency of 25 kHz, was introduced to overcome some of these problems. The horizontal vibration of the device is converted by a resonating ring in vertical vibration, resulting in a parallel movement of the working tip to the root surface. Furthermore, the energy from the instrument is transmitted to the root surface and the periodontal tissues by a suspension of hydroxyapatite (HA) particles and water, comparable to ultrasonic cleaning baths. The suspension is not sprayed in an aerosol by the instrument, but held hydrodynamically on the instrument by the linear ultrasonic movement (Hahn 2000). Preliminary clinical results have shown that the use of the VUS caused less pain during the treatment of periodontal lesions than the cleaning with hand instruments or a conventional ultrasonic system (Braun et al. 2003). It was suggested that a less painful treatment might increase patient compliance and give a better prognosis for the outcome of periodontal treatment. Furthermore, results from a recent study, evaluating the healing of human intrabony defects following non-surgical periodontal treatment with VUS clinically and histologically, have shown a significant gain of clinical attachment after six months. The histological evaluation revealed that healing was predominantly characterized by formation of a long junctional epithelium along the instrumented root surface (Sculean et al. 2003). However, until now very limited data are available concerning the clinical outcome following non-surgical periodontal treatment with VUS when compared to well established procedures such as scaling and root planing. Therefore, the aim of the present study was to assess the clinical effectiveness of VUS when compared to scaling and root planing with hand instruments.

Material and Methods

Subject selection

Thirty-eight patients (24 females and 14 males, mean age 54 years) diagnosed of advanced chronic periodontitis were included in the study based on signed informed consent. The study was in accordance with the Helsinki Declaration of 1975, as revised in 1983. Criteria for patient selection were: (a) no treatment of periodontitis for the last 2 years, (b) no use of antibiotics for the 12 months prior to treatment, (c) no systemic diseases, and (d) good level of oral hygiene. As criterion for a good level of oral hygiene a mean plaque index (PlI) score <1 was chosen (Löe 1967).

Oral hygiene program

For 6 weeks before treatment, all patients were enrolled in a hygiene program and received oral hygiene instructions on two to four appointments as well as professional supragingival tooth cleaning according to individual needs in order to ensure a high level of plaque control. A supragingival professional tooth cleaning and reinforcement of oral hygiene was performed at baseline as well as 4, 8, 12, 16, 20, and 24 weeks after treatment.

Study design and treatments

The study was performed according to a parallel group design. Allocation to treatment was performed by a toss of coin. All patients were treated according to an ''one-stage procedure'' with either (1) the VUS (Dürr Dental, Bietigheim-Bissingen, Germany) using straight and curved metal curettes and a polishing fluid (HA particles $<10\,\mu$m) according to the instructions given by the manufacturer (VUS) (19 patients, 10 females and nine males, mean age 55 years) or (2) scaling and root planing using hand instruments (Gracey Curettes, Hu-Friedy Co., Chicago, IL, USA) (SRP) (19 patients, 11 females and eight males, mean age 53 years). The straight Vector™ probe, in shape similar to a periodontal probe, was used for the instrumentation of all vestibular and oral surfaces. The Vector™ bent probe, shaped like an interradicular probe, was used for the instrumentation of furcations and the Vector™ curette was used for the cleaning of approximal surfaces. Following debridement, all pockets were thorougly rinsed with sterile saline to completely remove the HA. Instrumentation for both VUS and SRP was performed until the operator felt that the root surfaces were adequately debrided and planed. The amount of time needed in the VUS group was, on average, 6 min for single-rooted teeth and 10 min for multi-rooted teeth. In the SRP group, the averages were 8 min for single-rooted teeth and 12 min for multi-rooted teeth. In all cases, treatment was performed under local anesthesia by one experienced operator within 24 h. Only pockets exhibiting a probing depth of at least 4 mm were instrumented. In the VUS group, 319 single-rooted teeth and 249 multi-rooted teeth were treated. In the SRP group, 391 single-rooted and 298 multi-rooted teeth were treated. The frequency distribution of moderate (4–5 mm) and deep (>6 mm) pockets for single- and multi-rooted teeth in both treatment groups at baseline is shown in Fig. 1.

Clinical measurements

After the 6 weeks pre-treatment phase (baseline) and 6 months after therapy, the following clinical parameters were

measured by one calibrated periodontist who was not involved in providing treatment during the study: the full-mouth plaque score (FMPS) (O'Leary et al. 1972), probing depth (PD), gingival recession (GR), and the clinical attachment level (CAL). Bleeding on probing was assessed simultaneously to the pocket measurements, and the presence or absence of bleeding up to 30 s after probing was recorded. The measurements were made at six aspects per tooth: mesio-vestibular (mv), mid-vestibular (v), disto-vestibular (dv), mesio-oral (mo), mid-oral (o), and disto-oral (do) using a manual periodontal probe (PCP 12, Hu-Friedy Co., Chicago, IL, USA).

Statistical analysis

After completing the final examination, the statistical evaluations were conducted by a computer program (SPSS version 11.0, SPSS Inc., Chicago, IL, USA). For both groups the mean values of the clinical parameters were calculated. Normal distribution was looked for by the Kolmogorov–Smirnow test. The primary outcome variable was CAL. The Wilcoxon signed ranks test was used to compare the data from the baseline to those at 6 months for each treatment group. Comparisons between treatment groups at baseline and those at 6 months were accomplished with the Mann and Whitney *U*-test. The α error was set at 0.05. The power of the study, given 1 mm as a significant difference between groups, was calculated to be 0.99.

Intra-examiner reproducibility

Five patients, each showing two pairs of contralateral teeth (single- and multi-rooted) with probing depths >6 mm on at least one aspect of each tooth, were used to calibrate the examiner. The examiner evaluated the patients on two separate occasions, 48 h apart. Calibration was accepted if measurements at baseline and at 48 h were similar to the millimetre at >90% level.

Results

Clinical measurements

The postoperative healing was uneventful in all cases. No complications such as abscesses or infections were observed throughout the study period. At the baseline examination, there were no statistically significant differences in any of the investigated parameters (Tables 1–5). The FMPS and BOP for both treatment groups at baseline and 6 months are summarized in Table 1. At 6 months BOP improved statistically significantly compared to baseline, but no statistically significant differences were found between the two groups (Table 1).

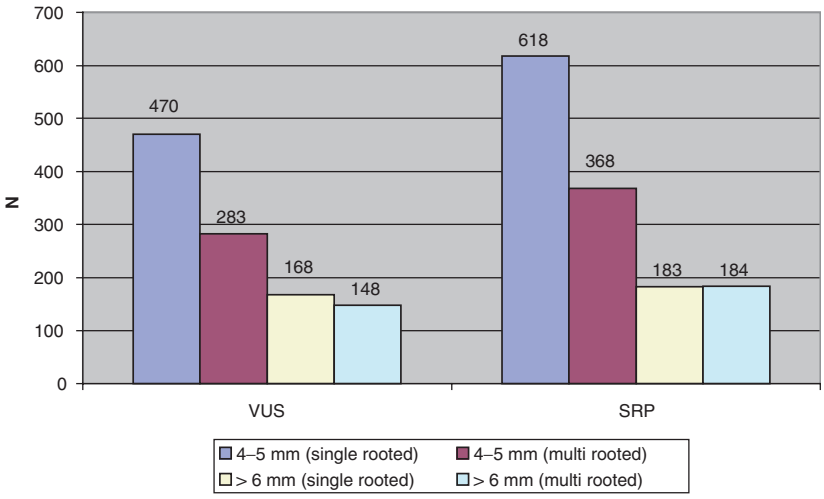

Fig. 1. Frequency distribution of moderate (4–5 mm) and deep (>6 mm) pockets in both treatment groups at baseline (single- and multi-rooted teeth).

Table 1. FMPS and BOP: mean scores (± SD, $n = 38$ patients) at baseline and 6 months

Index/treatment	Baseline (± SD)	6 months (± SD)	*p*-value
FMPS			
VUS	18%	4%	<0.001
SRP	25%	7%	<0.001
p-value	NS	NS	
BOP			
VUS	32%	20%	<0.001
SRP	30%	18%	<0.001
p-value	NS	NS	

Significance of differences within (Wilcoxon signed ranks test) and between (Mann and Whitney *U*-test) the groups at different time points ($p < 0.05$).
FMPS, full-mouth plaque score; BOP, bleeding on probing; VUS, Vector™-ultrasonic system; SRP, scaling and root planing; NS, not significant.

Table 2. Single-rooted teeth: mean PD, GR, and CAL (± SD) at baseline and 6 months at sites with initial pocket depths of 4–5 mm ($n = 38$)

Index/treatment	Baseline (± SD)	6 months (± SD)	*P* -value
PD			
VUS	4.5 ± 0.5	3.7 ± 1.2	<0.001
SRP	4.5 ± 0.3	3.4 ± 1.1	<0.001
p-value	NS	NS	
GR			
VUS	1.0 ± 1.0	1.2 ± 1.1	<0.001
SRP	1.1 ± 1.1	1.4 ± 1.1	<0.001
p-value	NS	NS	
CAL			
VUS	5.5 ± 1.0	4.9 ± 1.7	<0.001
SRP	5.6 ± 1.1	4.8 ± 1.5	<0.001
p-value	NS	NS	

Significance of differences within (Wilcoxon signed ranks test) and between (Mann and Whitney *U*-test) the groups at different time points ($p < 0.05$).
PD, probing depth; GR, gingival recession; CAL, clinical attachment level; VUS, Vector™-ultrasonic system; SRP, scaling and root planing; NS, not significant.

Table 3. Single-rooted teeth: mean PD, GR, and CAL (± SD) at baseline and 6 months at sites with initial pocket depths of >6 mm ($n = 38$)

Index/treatment	Baseline (± SD)	6 months (± SD)	*P*-value
PD			
VUS	7.2 ± 1.5	6.6 ± 1.9	<0.001
SRP	6.6 ± 0.9	5.4 ± 1.8	<0.001
p-value	NS	NS	
GR			
VUS	1.6 ± 1.2	1.7 ± 1.2	<0.001
SRP	1.4 ± 1.1	1.9 ± 1.1	<0.001
p-value	NS	NS	
CAL			
VUS	8.8 ± 2.1	8.3 ± 2.4	<0.001
SRP	8.0 ± 1.4	7.3 ± 2.1	<0.001
p-value	NS	NS.	

Significance of differences within (Wilcoxon signed ranks test) and between (Mann and Whitney *U*-test) the groups at different time points: ($p < 0.05$).
PD, probing depth; GR, gingival recession; CAL, clinical attachment level; VUS, Vector™-ultrasonic system; SRP, scaling and root planing; NS, not significant.

Table 4. Multi-rooted teeth: mean PD, GR, and CAL (± SD) at baseline and 6 months at sites with initial pocket depths of 4–5 mm ($n = 38$)

Index/treatment	Baseline (± SD)	6 months (± SD)	*p*-value
PD			
VUS	4.5 ± 0.5	3.7 ± 1.1	<0.001
SRP	4.5 ± 0.5	3.7 ± 1.2	<0.001
p-value	NS	NS	
GR			
VUS	1.0 ± 1.0	1.2 ± 1.0	<0.001
SRP	1.2 ± 1.1	1.5 ± 1.1	<0.001
p-value	NS	NS	
CAL			
VUS	5.5 ± 1.0	4.9 ± 1.6	<0.001
SRP	5.7 ± 1.1	5.2 ± 1.5	<0.001
p-value	NS	NS	

Significance of differences within (Wilcoxon signed ranks test) and between (Mann and Whitney *U*-test) the groups at different time points ($p < 0.05$).
PD, probing depth; GR, gingival recession; CAL, clinical attachment level; VUS, Vector™-ultrasonic system; SRP, scaling and root planing; NS, not significant.

Table 5. Multi-rooted teeth: mean PD, GR, and CAL (± SD) at baseline and 6 months at sites with initial pocket depths of >6 mm ($n = 38$)

Index/treatment	Baseline (± SD)	6 months (± SD)	*p*-value
PD			
VUS	6.8 ± 1.2	5.9 ± 1.9	<0.001
SRP	6.6 ± 1.0	5.5 ± 1.8	<0.001
p Value	NS	NS	
GR			
VUS	1.3 ± 1.2	1.5 ± 1.2	<0.001
SRP	1.3 ± 1.2	1.7 ± 1.1	<0.001
p-value	NS	NS	
CAL			
VUS	8.1 ± 1.7	7.4 ± 2.3	<0.001
SRP	7.9 ± 1.7	7.2 ± 2.2	<0.001
p-value	NS	NS	

Significance of differences within (Wilcoxon signed ranks test) and between (Mann and Whitney *U*-test) the groups at different time points ($p < 0.05$).
PD, probing depth; GR, gingival recession; CAL, clinical attachment level; VUS, Vector™-ultrasonic system; SRP, scaling and root planing; NS, not significant.

At moderately deep sites (initial PD 4–5 mm) mean CAL changed in the test group from 4.6 ± 1.2 to 4.2 ± 1.6 mm ($p < 0.001$) and in the control group from 4.8 ± 1.3 to 4.4 ± 1.5 mm ($p < 0.001$). At deep sites (inital PD > 6 mm) mean CAL changed in the test group from 8.5 ± 1.9 to 7.9 ± 2.4 mm ($p < 0.001$) and in the control group from 7.9 ± 1.6 to 7.2 ± 2.2 mm ($p < 0.001$). However, no statistically significant difference was observed between the two groups. The effect of VUS and SRP at different initial pocket depths of single- or multi-rooted teeth is shown in Tables 2–5. Initially deeper pockets (>6 mm) showed the greatest changes in the PD, GR, and the CAL. Moderately deep pockets (4–5 mm) showed more moderate improvements. In particular, sites where probing depths were initially deep showed more GR, more gain of CAL and deeper residual PD at the 6-month examination than sites with initial moderate PD. No statistically significant difference was observed between the two groups (Tables 2–5).

Discussion

The present study has shown that non-surgical periodontal treatment with both VUS and SRP may lead to clinically and statistically PD reduction and CAL gain. The fact that all pockets treated in this study healed uneventfully suggests that both treatment modalities were well tolerated. However, no statistical and clinical differences in any of the investigated parameters were observed between both treatment modalities. When interpreting the present results, it has also to be noted that sites where probing depths were initially deep showed more GR, more gain of CAL, and deeper residual PD at the 6-month examination than sites with initial moderate PD. In the present study, the SRP group showed at initially moderately deep sites a mean CAL gain of 0.4 ± 0.3 mm, and of 0.7 ± 0.4 mm at initially deep sites 6 months postoperatively. The finding that non-surgical periodontal treatment with hand instruments may result in significant short-term improvements in terms of PD reduction and CAL gain is consistent with previously published data (Lindhe et al. 1984, Badersten et al. 1987, Ramfjord et al. 1987, Kaldahl et al. 1993, 1996, Serino et al. 2001). So far, there is only one published study available reporting on the clinical and histological outcome following non-surgical periodontal therapy with VUS (Sculean et al. 2003). The mean PD decreased from 7.5 ± 1.0 mm at baseline to 5.3 ± 0.9 mm after 6 months and

mean CAL decreased from 10.0 ± 1.3 mm at baseline to 8.5 ± 0.8 mm after 6 months. However, the histologic evaluation showed that healing occurred consistently through formation of a long junctional epithelium along the instrumented root surface. In the present study, the VUS group showed at initially moderately deep sites a mean CAL gain of 0.4 ± 0.2 mm, and of 0.6 ± 0.4 mm at initially deep sites 6 months postoperatively. Furthermore, a comparison with the clinical results obtained after instrumentation using conventional ultrasonic systems is difficult. On the other hand, the present clinical findings corroborate, to a certain extent, results from recent controlled clinical studies evaluating non-surgical periodontal treatment using ultrasonic devices. Unfortunately, most clinical studies have not evaluated attachment level changes. Two months after ultrasonic instrumentation Torfason et al. (1979) reported in a controlled study a mean PD decrease of 1.7 mm (baseline PD: 5.0 mm). There was no statistically significant difference between ultrasonic and hand instrumentation. Badersten et al. (1981) reported a mean PD decrease of 1.3 mm after 13 months for both ultrasonic and hand instrumentation (baseline PD: 4.2 mm); and Loos et al. (1989) reported a mean PD increase of 0.5 mm for initially shallow sites (<3.5 mm), a mean PD decrease of 1.2 mm for moderately deep pockets (4–6.5 mm) and 2.3 mm for deep pockets (>7 mm) with a mean CAL gain of 0.6 mm 24 months postoperatively. One month postoperatively, Boretti et al. (1995) reported a mean PD decrease of 1.82 mm and a mean CAL gain of 1.14 mm for ultrasonic scaling. The reported mean PD reductions and CAL gains were higher than that from the present study. There might be several explanations for these findings. First of all, it is important to point out that this discrepancy might be explained by differences in the initial PD. Clinical studies have demonstrated that the reduction of the PD and the improvement of the CAL after both, non-surgical and surgical periodontal treatment, are dependent on the initial PD (Ramfjord et al. 1987, Kaldahl et al. 1996). Another important factor that was demonstrated to influence the outcome of non-surgical periodontal treatment is the removal of subgingival calculus and the detoxification of the root surface (Badersten et al. 1981, Nyman et al. 1986, Kepic et al. 1990). Several studies have demonstrated that ultrasonic instrumentation achieves equal or superior treatment outcomes when compared with hand instruments (Torfason et al. 1979, Badersten et al. 1984, Loos et al. 1987, Dragoo 1992). In contrast, studies evaluating root surface alterations produced by ultrasonic instruments suggest that this treatment modality does less damage to the root surface than hand instruments (Dragoo 1992, Jacobson et al. 1994). In this context, it is important to point to the results of a recent in vitro study which have shown that the treatment of the root surface with VUS using the straight metal probe and the polishing fluid resulted in a less effective removal of subgingival debris, but preservation of more tooth substance than a conventional ultrasonic system (Hartschen & Frentzen 2002). Because no previously published data on the influence of VUS on the biocompatibility of periodontally diseased root surfaces are available, it is impossible to estimate to what extent the used polishing fluid, containing HA, influenced cellular attachment to the root surface. Further studies are needed in order to clarify this issue.

Within the limits of the present study, it may be concluded that non-surgical periodontal therapy with the tested ultrasonic device may lead to clinical improvements comparable to those obtained with conventional hand instruments.

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Address:
Anton Sculean
Department of Conservative Dentistry and Periodontology
Johannes Gutenberg-University
55131 Mainz, Germany
Fax: +49 6551 7499
E-mail: anton.sculean@gmx.de