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One-stage full-mouth disinfection *versus* quadrant and full-mouth root planing

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Abstract

Objective: The aim of this study was to test the hypothesis that the one-stage full-mouth disinfection (FMD) provides greater clinical and microbiological improvement compared with full-mouth scaling and root planing (FM-SRP) within 24 h and quadrant scaling and root planing (Q-SRP) in patients with generalized chronic periodontitis.

Material & Methods: Twenty-eight patients were randomized into three groups. 25 patients completed the study and were the basis for analysis. The Q-SRP group was scaled quadrant-wise at 1-week intervals. The other groups received a one-stage full-mouth scaling with (FMD) and without (FM-SRP) chlorhexidine. At baseline, after 1, 2, 4 and 8 months clinical parameters were recorded and microbiological analysis was performed.

Results: All three treatment modalities resulted in significant clinical improvement at any time. There were only group differences after 1 and 2 months: in the FM-SRP group was a significantly higher reduction of probing depth and bleeding on probing compared with the other two groups. The bacteria could be reduced in every group although this reduction was only significant for *Prevotella intermedia* in the FMD group 8 months after treatment.

Conclusion: All three treatment modalities lead to an improvement of the clinical and microbiological parameters, however, without significant group differences after 8 months.

Key words: bacterial infection; chlorhexidine; chronic periodontitis; full-mouth disinfection; root planing

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The treatment of inflammatory periodontal diseases comprises mainly the reduction or elimination of bacteria. However, it is questionable, if a predictable reduction of bacteria can be achieved in the long term. It has been shown that periodontopathogens can establish not only in periodontal pockets but also on the tongue, tonsils or on other oral mucous membranes (Van Winkelhoff et al. 1988). Therefore, they can cause a re-infection of the periodontal pockets after periodontal treatment (Van Winkelhoff et al. 1988). In order to minimize the risk of bacterial translocation, Quirynen et al. (1995) introduced the ''one-stage full-mouth disinfection'', where scaling and root planing was performed in two sessions within 24 h supplemented with supra- and subgingival use of chlorhexidine. Using this protocol, several long-term studies have reported significant improvements of the clinical and microbiological parameters in patients with advanced chronic periodontitis in comparison with conventional periodontal treatment (Bollen et al. 1996, Vandekerckhove et al. 1996). Also in patients with early onset periodontitis, similar improvements of the clinical and microbiological outcomes could be achieved with this treatment (Mongardini et al. 1999, Quirynen et al. 1999).

A long-term study investigated whether the positive effect was due to the additional use of chlorhexidine or to scaling and root planing alone within 24 h (Quirynen et al. 2000). No additional improvement was achieved with the adjunctive use of chlorhexidine, it seems that the positive results of the ''one-stage full-mouth disinfection'' were due to mechanical cleaning within this short time period.

Conflict of interest and source of funding statement

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Further studies compared the quadrant-wise mechanical periodontal therapy with the treatment within 24 h without the additional use of chlorhexidine (Apatzidou & Kinane 2004, Wennström et al. 2005, Jervøe-Storm et al. 2006). In all studies, no significant differences could be found 6 months after treatment with respect to clinical data. Another study that compared the same treatment modalities also could not show significant differences in both clinical and microbiological parameters 6 months after treatment (Koshy et al. 2005). One study could not even confirm differences in re-colonization after scaling and root planing within 24 h compared with treatment over several sessions (Jervøe-Storm et al. 2007b). Nevertheless, both treatment modalities obtained mean count reductions of the target bacteria after 6 months.

The aim of this study was to test the hypothesis that the ''one-stage full-mouth disinfection'' results in greater clinical and microbiological improvement compared with full-mouth scaling and root planing (FM-SRP) within 24 h and quadrant scaling and root planing (Q-SRP) in patients with generalized chronic periodontitis.

Material and Methods

Patients

Five male and 20 female patients (28–63 years, mean: 45 years) with generalized chronic periodontitis (Armitage 1999) were included in the study (Table 1). All subjects were recruited from the Department of Periodontology, Philipps University, Marburg, Germany. None of the patients had a history of systemic diseases (e.g. cardiovascular diseases, diabetes mellitus, osteoporosis) and none had used antibiotics or antiseptics 6 months before the study. Patients had more than 20 teeth with at least six sites probing depth (PD) of 5 mm or more and bleeding on probing (BOP). Third molars were not included. Teeth with furcation involvement of degree II and III (Hamp et al. 1975) were not included into examination. There were no extractions 6 months before the study. Orthodontic treatment and pregnancy were not compatible with the participation in the study. Patients that were smoking at least 10 cigarettes a day for more than 5 years were considered as smokers ($n = 5$) (Kinane & Radvar 1997).

Study design

This is a randomized prospective clinical long-term study. It followed the guidelines of the World Medical Association Declaration of Helsinki (version VI, 2002). Informed consent was obtained from each patient.

After screening, the patients received repeated oral hygiene instructions and supragingival tooth cleanings until they had an approximal plaque index (API) $\leqslant 20\%$ (Lange 1978). Before the beginning of the study, single dental intra-oral radiographs using paralleling long tubus technique were taken to classify the periodontitis.

The randomization was performed with a combination of coin toss and drawing of lots by a second person not involved in the study to assign the patients into the following groups: full-mouth disinfection (FMD), FM-SRP and Q-SRP. The sequence was concealed until interventions were assigned.

Treatment

The treatment and reassessment were performed by one periodontist who had been trained and tested previously for his reproducibility. The correlation coefficient for his repeated measurements was between 0.8 and 0.9. The CEJ, alternatively the crown margin served as reference structure.

To maintain the low baseline plaque score (API $\leqslant 20\%$), oral hygiene instructions were re-enforced after 1, 2, 4 and 8 months.

Scaling and root planing was performed without local anaesthesia using periodontal hand instruments (Gracey curets, scaler, Hu-Friedy, Chicago, IL, USA) and ultrasonic devices (Piezon® Master 600, EMS, Nyon, Switzerland) quadrant per quadrant starting in the upper right jaw and going clockwise.

In the FMD-group, scaling and root planing was performed in two sessions within 24 h and additionally chlorhexidine gel 1% was applied once subgingivally (Chlorhexamed-Gel®, GlaxoSmithKline, Bühl, Germany). The dorsum of the tongue was brushed for 1 min. with 1% chlorhexidine gel (Chlorhexamed-Gel®, GlaxoSmithKline), each tonsil was sprayed four times with 0.2% chlorhexidine spray (Chlorhexamed forte®, GlaxoSmithKline) and the patients were instructed to rinse twice for 1 min. with 0.2% chlorhexidine solution (Chlorhexamed Forte®, GlaxoSmith Kline). For 14 days after the treatment, the patients were instructed to rinse once daily for 30 s with 0.2% chlorhexidine solution and also spray the tonsils once daily with 0.2% spray.

In the FM-SRP-group, scaling and root planing was performed in two sessions within 24 h. No additional antiseptics were used in this group.

In the Q-SRP-group, scaling and root planing were performed quadrant-wise in weekly intervals and no additional antiseptics were used.

Clinical parameters

Clinical parameters were recorded at baseline, 1, 2, 4 and 8 months after treatment with a standardized periodontal probe (PCPUNC 15, Hu-Friedy). PD, clinical attachment level (CAL) and BOP were recorded for each tooth at four sites (mesial, distal, buccal and oral). The plaque index (PlI) (Silness & Löe 1964) was also assessed at the same sites and the same time points after disclosure with a 7% erythrosine solution. API (Lange 1978) was recorded at

Table 1. Demographic details for the quadrant scaling and root planing (Q-SRP), full-mouth disinfection (FMD) and full-mouth scaling and root planing (FM-SRP) groups

	No. of subjects	Age	Females	Males	Smokers	No. of sites single-rooted teeth (4 mm $\leqslant$ PD $\leqslant$ 6 mm)	No. of sites multi-rooted teeth (4 mm $\leqslant$ PD $\leqslant$ 6 mm)	No. of sites single- and multi-rooted teeth (PD $\geqslant$ 7 mm)
Q-SRP	7	48 (35–63)	6	1	1	113	94	50
FMD	9	50 (35–62)	7	2	1	144	114	76
FM-SRP	9	39 (28–46)	7	2	3	144	121	20

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the inter-proximal surfaces of the teeth as present or absent and calculated in percent on the basis of total measurement points.

Sampling

The subgingival microbial samples were collected from the four deepest periodontal pockets at baseline, 24 h, 1, 2, 4 and 8 months after treatment. The single samples 24 h after treatment from the Q-SRP group were only taken from the treated quadrant and were pooled at the later evaluation. The sampling area was isolated with cotton rolls; supragingival plaque was removed and carefully dried with sterile cotton pellets. The sterile paper points (ISO 30, Antaeos, Munich, Germany) were inserted to the bottom of the pocket for 20 s and the pooled samples were stored in a labelled sterile Eppendorf tube containing reduced transport fluid (RTF) medium with 25% glucose and then frozen at -80°C pending the analysis. The subgingival sampling 24 h after treatment from the Q-SRP group was performed collecting one single paperpoint from each treated quadrant. These subgingival samples were pooled at the later evaluation. DNA from all subgingival clinical samples was isolated using DNeasy tissue kit (Qiagen, Hilden, Germany) according to manufacturer's instructions.

Microbiological analysis

Samples were evaluated using a real-time PCR method as previously described (Nonnenmacher et al. 2004). Species-specific probe and primer sets were designed based upon the variable regions of the 16S rRNAs of *Aggregatibacter actinomycetemcomitans*, *Porphyromonas gingivalis*, *Prevotella intermedia*, *Dialister pneumosintes*, *Camplyobacter rectus* and *Parvimonas micra*. Additionally, a universal bacterial primer pair was used to detect DNA from all eubacterial species present in the samples. The fluorescent dyes at the 5′ and at the 3′ ends of the probe were FAM (6-carboxyfluorescein; reporter) and TAMRA (6-carboxytetramethylrhodamine; quencher), respectively. All primers and probes were checked for possible cross-hybridization with bacterial genes using the database similarity search program BLAST (Altschul et al. 1990).

Plasmid standards and clinical samples were run in duplicates and the average values were used for calculation of the bacterial load. Samples were assayed in duplicate in a 25-μl reaction mixture containing 2.5 μl of template DNA, 2.5 μl of 10 × buffer with ROX, 1.5 μl of 50 mM $MgCl_2$, 1 μl dNTP (qPCR Core Kit, Eurogentec, Belgium), 12.5 pmol of forward primer and reverse primer and 3.75 pmol of the probe (MWG, Munich, Germany). The cycling conditions used were as follows: 95°C for 10 min., followed by 40 cycles at 95°C for 15 s and 60°C for 1 min. each. During the annealing-extension step, the ABI Prism 7700 SDS (Applied Biosystems Inc., Foster City, CA, USA) monitored real-time PCR amplification by quantitatively analysing fluorescence emissions. The reporter dye (FAM) signal was measured relative to the reference dye (ROX) as present in the PCR master mix to normalize for non-PCR related fluorescence fluctuations occurring from well to well. All PCRs were performed in duplicate.

The detection limit of the real-time PCR assays was deduced to be 10^2 copies of templates in the reaction tube. The linearity of the quantification was demonstrated over a range of six to seven log steps (10^8–10^2 plasmid copies) as already published (Nonnenmacher et al. 2004). The samples were assigned consecutive numbers for microbiological analysis and were then analysed all together at the end of the study by an independent, blinded examiner.

Statistical analysis

The statistical analysis was performed with the software SPSS 10.0.5 for Windows (SPSS, Chicago, IL, USA). The primary outcome was the reduction in PD. The study had a power of 0.688 to detect a difference of Delta = 0.47 (with respect to a standard deviation of 0.9). The normal distribution of the clinical parameters was detected with the Kolmogorov–Smirnow test. To evaluate the microbiological parameters, non-parametric tests were used because the assumption of normal distribution could not be confirmed. The hypothesis of equality of the values in the FMD group was tested for the different points in time with the *F*-test for the ANOVA analysis (for normal distribution) and with the Kruskal–Wallis test (no normal distribution). With normal distribution the assumption of the regular course of the group profiles at the points in time was tested with the ANOVA analysis with repeated measurements. The assumption of equality of the (mean-) values between consecutive points in time for the single points in time was tested with the *t*-test (for normal distribution) and with the Wilcoxon test (no normal distribution). The correlation between the clinical and microbiological parameters was evaluated with the Spearman correlation. Statistical significance was considered $p \leqslant 0.01$.

Results

One patient in every group was excluded from the study due to prescribed antibiotics because of sinusitis maxillaris. The patient of the FM-SRP group dropped out 2 months after treatment and the two patients of the other two groups dropped out 4 months after treatment. Their data were not included into the statistical analysis. None of the patients reported any adverse events or side effects.

In all three groups, significant reductions of the clinical parameters could be observed at every examination time compared with baseline (Table 2). PD reduction and CAL were significantly greater in the FM-SRP group than in the Q-SRP group 2 months after treatment. However, this difference did not remain after 4 and 8 months.

For moderate pockets (4–6 mm) of single-rooted teeth PD reduction was significantly higher in the FM-SRP group after 1, 2 and 4 months than in the Q-SRP and FMD group (Table 3). CAL was significantly lower in the FMD group than in the other groups after 1 and 2 months. After 2 months, BOP was significantly lower for the FM-SRP group than for the other two groups, but there were no group differences for all clinical parameters after 8 months.

Moderate pockets of multi-rooted teeth showed a significantly greater PD reduction and CAL after 4 months for the FM-SRP group than for the other groups (Table 4). After 1 and 2 months, PD reduction was significantly lower for the FMD group in contrast to the other groups. After 2 and 4 months, BOP was reduced significantly more in the FM-SRP group than in the other groups. However, at the end of the study there were no group differences.

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Table 2. Whole-mouth clinical findings (mean ± SD)

	Baseline	1 month	2 months	4 months	8 months	Baseline – 1 month (mm)	Baseline – 2 months (mm)	Baseline – 4 months (mm)	Baseline – 8 months (mm)
PD (mm)									
Q-SRP	3.60 ± 0.90	3.20 ± 0.96	3.17 ± 0.89	2.92 ± 0.99	2.64 ± 0.53	0.4 ± 0.14*	0.44 ± 0.12*	0.69 ± 0.22*	0.93 ± 0.79
FMD	3.55 ± 0.88	2.91 ± 0.80	2.90 ± 0.85	2.67 ± 0.80	2.73 ± 0.74	0.64 ± 0.31*	0.65 ± 0.28*	0.87 ± 0.32*	0.80 ± 0.41*
FM-SRP	3.20 ± 0.57	2.58 ± 0.41	2.39 ± 0.41	2.39 ± 0.35	2.44 ± 0.35	0.62 ± 0.22*	0.81 ± 0.31*†‡	0.69 ± 0.27*	0.80 ± 0.41*
CAL (mm)									
Q-SRP	4.21 ± 1.04	3.80 ± 1.08	3.70 ± 1.00	3.40 ± 1.04	3.10 ± 0.59	0.41 ± 0.33*	0.51 ± 0.23*	0.81 ± 0.46*	0.98 ± 0.69*
FMD	4.20 ± 0.69	3.63 ± 0.68	3.60 ± 0.74	3.37 ± 0.67	3.35 ± 0.67	0.57 ± 0.19*	0.60 ± 0.25*	0.83 ± 0.24*	0.84 ± 0.32*
FM-SRP	3.68 ± 0.93	3.19 ± 0.92	3.02 ± 0.94	3.13 ± 1.09	3.15 ± 0.85	0.50 ± 0.12*	0.66 ± 0.20*	0.56 ± 0.14*	0.67 ± 0.25*
BOP (%)									
Q-SRP	37.0 ± 23.0	21.0 ± 22.0	11.0 ± 14.0	19.0 ± 21.0	11.0 ± 16.0	0.16 ± 0.15	0.26 ± 0.14*	0.18 ± 0.06*	0.23 ± 0.22
FMD	37.0 ± 13.0	15.0 ± 7.0	14.0 ± 13.0	13.0 ± 11.0	13.0 ± 9.0	0.22 ± 0.15*	0.22 ± 0.16*	0.23 ± 0.15*	0.23 ± 0.14
FM-SRP	29.0 ± 20.0	9.0 ± 6.0	8.0 ± 9.0	13.0 ± 13.0	11.0 ± 8.0	0.20 ± 0.16*	0.21 ± 0.19*	0.23 ± 0.24	0.15 ± 0.18
PII									
Q-SRP	32.0 ± 23.0	22.0 ± 9.0	22.0 ± 24.0	29.0 ± 37.0	27.0 ± 14.0	9.0 ± 18.0	9.0 ± 29.0	2.0 ± 43.0	4.0 ± 24.0
FMD	25.0 ± 21.0	19.0 ± 27.0	20.0 ± 12.0	14.0 ± 8.0	20.0 ± 14.0	6.0 ± 35.0	5.0 ± 24.0	12.0 ± 14.0	2.0 ± 24.0
FM-SRP	17.0 ± 16.0	17.0 ± 14.0	17.0 ± 18.0	22.0 ± 26.0	29.0 ± 30.0	0.0 ± 9.0	0.0 ± 23.0	− 7.0 ± 22.0	− 11.0 ± 18.0
API									
Q-SRP	11.57 ± 4.43	20.71 ± 11.69	17.54 ± 18.14	20.57 ± 27.01	25.83 ± 7.83	− 9.14 ± 15.24	− 6.00 ± 15.48	− 9.00 ± 24.57	− 15.17 ± 8.61
FMD	11.56 ± 5.94	18.33 ± 25.05	16.67 ± 12.17	9.00 ± 6.76	25.00 ± 21.55	− 6.78 ± 21.54	− 5.11 ± 11.37	2.56 ± 4.33	±13.50 ± 22.85
FM-SRP	11.56 ± 7.25	15.78 ± 10.55	4.56 ± 17.81	2.83 ± 31.15	24.71 ± 25.96	− 4.22 ± 8.74	− 3.00 ± 17.01	− 12.17 ± 27.61	− 12.43 ± 23.85

*Significant ($p \leqslant 0.01$) differences of the difference to baseline (paired *t*-test).
†Significant differences between FM-SRP and Q-SRP (*F*-test of the ANOVA analysis).
‡Significant differences between FM-SRP and FMD (*F*-test of the ANOVA analysis).
Q-SRP, quadrant scaling and root planing; FMD, full-mouth disinfection; FM-SRP, full-mouth scaling and root planing; PD, probing depth; CAL, clinical attachment level; BOP, bleeding on probing; PII, plaque index; API, approximal plaque index.

Throughout the study the differences in PD for moderate pockets compared with baseline were higher for single-rooted than for multi-rooted teeth (Tables 3 and 4).

Because of the small number of deep pockets ($\geqslant$7 mm), the validity is low and so deep pockets of single- and multi-rooted teeth were evaluated together (Table 5). After 1 and 2 months PD, CAL and BOP could be reduced significantly more in the FM-SRP group than in the other 2 groups. However, there were no group differences after 8 months.

The microbiological outcomes show that periodontopathogens could be reduced in all tested groups. A significant reduction in total bacterial load (eubacteria) was observed after 8 months in the FMD group (Fig. 1a). In all groups, a major decrease was detected 24 h after treatment followed by an additional decrease after 8 months. Similar results were observed for *A. actinomycetemcomitans* that reached its highest reduction after 24 h and was still significantly reduced in the Q-SRP and FM-SRP group after 8 months (Fig. 1b). After 8 months the bacterial counts for *A. actinomycetemcomitans* significantly correlated with the PD in the FM-SRP group (Table 6). *P. gingivalis* was reduced after 8 months for all groups (Fig. 1c). *P. micra* remained nearly unchanged after 8 months (Fig. 1d) and showed the only significant positive correlation with PD in the FM-SRP group at this time (Table 6). *D. pneumosintes* showed a significant decrease after 24 h in the FM-SRP group; however, this difference did not remain after 8 months (Fig. 1e). *P. intermedia* showed a very variable pattern (Fig. 1f). The greatest decrease was observed after 24 h in all groups tested. There was a significant positive correlation after 8 months between the mean counts of *P. intermedia* and PD in the FM-SRP group (Table 6).

No correlation could be found for the smoking habits (smoker/non-smoker), gender and age of the patients with regards to the treatment outcomes (data not shown).

Discussion

The ''one-stage full-mouth disinfection'' concept was introduced to improve the results of subgingival scaling in the treatment of chronic perio-

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Table 3. Selected-site analysis (mean ± SD), moderate pockets of single-rooted teeth (4 mm ⩽ PD ⩽ 6 mm)

	Baseline	1 month	2 months	4 months	8 months	Baseline – 1 month (mm)	Baseline – 2 months (mm)	Baseline – 4 months (mm)	Baseline – 8 months (mm)
PD (mm)									
Q-SRP	4.67 ± 0.03	3.42 ± 0.14	3.33 ± 0.15	2.41 ± 0.25	2.67 ± 0.17	1.25 ± 0.11*	1.34 ± 0.12*	2.26 ± 0.22*	2.00 ± 0.17*
FMD	4.74 ± 0.04	3.60 ± 0.04	3.52 ± 0.04	2.81 ± 0.09	2.66 ± 0.05	1.15 ± 0.02*	1.23 ± 0.01*	1.94 ± 0.05*	2.09 ± 0.05*
FM-SRP	4.83 ± 0.25	3.37 ± 0.15	3.26 ± 0.14	1.94 ± 0.65	2.4 ± 0.42	1.47 ± 0.14*†‡	1.57 ± 0.15*†‡	2.89 ± 0.45*†‡	2.19 ± 0.26*
CAL (mm)									
Q-SRP	5.12 ± 0.12	4.00 ± 0.16	3.92 ± 0.16	2.90 ± 0.24	3.16 ± 0.13	1.12 ± 0.07*§	1.20 ± 0.08*§	2.22 ± 0.15*	1.96 ± 0.19*
FMD	5.23 ± 0.01	4.21 ± 0.04	4.12 ± 0.04	3.30 ± 0.09	3.14 ± 0.06	1.02 ± 0.04*	1.11 ± 0.04*	1.92 ± 0.08*	2.09 ± 0.06*
FM-SRP	5.51 ± 0.66	4.27 ± 0.65	4.27 ± 0.72	2.89 ± 1.22	3.55 ± 0.92	1.24 ± 0.04*†‡	1.25 ± 0.08*†‡	2.63 ± 0.61*‡	1.96 ± 0.34*
BOP (%)									
Q-SRP	46.0 ± 4.0	19.0 ± 4.0	15.0 ± 1.0	22.0 ± 3.0	20.0 ± 4.0	27.0 ± 2.0*	31.0 ± 4.0*	24.0 ± 2.0*	26.0 ± 4.0*
FMD	49.0 ± 1.0	22.0 ± 1.0	17.0 ± 1.0	24.0 ± 1.0	18.0 ± 1.0	27.0 ± 1.0*	32.0 ± 2.0*	25.0 ± 1.0*	31.0 ± 1.0*
FM-SRP	43.0 ± 0.14	14.0 ± 4.0	19.0 ± 8.0	16.0 ± 7.0	18.0 ± 6.0	29.0 ± 10.0*	24.0 ± 7.0*†‡	27.0 ± 8.0*	25.0 ± 9.0*
PII									
Q-SRP	24.0 ± 3.0	18.0 ± 2.0	18.0 ± 3.0	25.0 ± 4.0	23.0 ± 3.0	6.0 ± 2.0*	7.0 ± 3.0*	0.0 ± 3.0	2.0 ± 4.0
FMD	29.0 ± 1.0	19.0 ± 1.0	20.0 ± 0.0	26.0 ± 1.0	23.0 ± 1.0	10.0 ± 2.0*	9.0 ± 1.0*	3.0 ± 2.0*	6.0 ± 2.0*
FM-SRP	21.0 ± 4.0	21.0 ± 2.0	15.0 ± 4.0	9.0 ± 8.0	36.0 ± 12.0	0.0 ± 4.0†‡	5.0 ± 7.0	12.0 ± 9.0*†‡	− 15.0 ± 11.0*†‡

*Significant ($p \leqslant 0.01$) differences of the difference to baseline (paired *t*-test).
†Significant differences between FM-SRP and Q-SRP (*F*-test of the ANOVA analysis).
‡Significant differences between FM-SRP and FMD (*F*-test of the ANOVA analysis).
§Significant differences between Q-SRP and FMD (*F*-test of the ANOVA analysis).
Q-SRP, quadrant scaling and root planing; FMD, full-mouth disinfection; FM-SRP, full-mouth scaling and root planing; PD, probing depth; CAL, clinical attachment level; BOP, bleeding on probing; PII, plaque index.

dontitis (Quirynen et al. 1995). Chlorhexidine was used as an adjunct to therapy because of the local plaque- and gingivitis inhibitory effects and to minimize the bacterial translocation. The treatment concept led to a significant reduction of PDs and greater gains of clinical attachment in patients with chronic periodontitis than the conventional treatment (Quirynen et al. 1995). These results could not be confirmed by other studies showing that chlorhexidine does not improve periodontal treatment (Braatz et al. 1985, MacAlpine et al. 1985, Lander et al. 1986, Wennström et al. 1987a, b, Oosterwaal et al. 1991, Quirynen et al. 2000). In our study group, differences were neither found in the clinical parameters nor in the microbiological outcomes throughout the study with the adjunctive use of chlorhexidine. Although the examiner was not blinded in this study and the assignment into different groups should preferably be performed computer-based for this kind of study design, it remains questionable if the allocation concealment and the examiner masking have an actual effect on clinical outcomes (Fenwick et al. 2008).

Besides the effect of chlorhexidine, the benefits of the ''one-stage full-mouth disinfection'' arose according to the FM-SRP within 24 h. In other studies, patients with advanced chronic periodontitis were either scaled and root planed quadrant per quadrant in 2-week intervals or they underwent a FM-SRP in 24 h with or without the adjunctive use of chlorhexidine (Mongardini et al. 1999, Quirynen et al. 2000). Patients in both full-mouth treatment groups reacted significantly more favourable than patients that were scaled and root planed quadrant-wise, with additional PD reductions and gains in clinical attachment after 1 and 2 months. The group differences between these two groups were negligible.

These results could not be confirmed by other studies showing no difference between scaling and root planing within 24 h and the conventional quadrant-wise treatment (Apatzidou & Kinane 2004, Koshy et al. 2005, Wennström et al. 2005, Jervøe-Storm et al. 2006). This could also be shown in our study. After 8 months, all treatment modalities lead to comparable clinical improvements.

A systematic review substantiated that full-mouth debridement with and without antiseptics does not provide clinically relevant advantages over con-

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Table 4. Selected-site analysis (mean ± SD), moderate pockets of multi-rooted teeth (4 mm ⩽ PD ⩽ 6 mm)

	Baseline	1 month	2 months	4 months	8 months	Baseline – 1 month (mm)	Baseline – 2 months (mm)	Baseline – 4 months (mm)	Baseline – 8 months (mm)
PD (mm)									
Q-SRP	4.82 ± 0.02	3.78 ± 0.10	3.70 ± 0.11	2.89 ± 0.24	3.4 ± 0.11	1.05 ± 0.09*†	1.13 ± 0.10*†	1.94 ± 0.23*	1.59 ± 0.11*
FMD	4.84 ± 0.02	3.91 ± 0.01	3.86 ± 0.02	3.27 ± 0.06	3.26 ± 0.05	0.93 ± 0.02*	0.97 ± 0.02*	1.57 ± 0.04*	1.57 ± 0.04*
FM-SRP	4.93 ± 0.10	3.82 ± 0.20	3.72 ± 0.23	2.00 ± 0.80	3.37 ± 0.46	1.11 ± 0.11*‡	1.21 ± 0.14*‡	2.94 ± 0.86*§‡	1.57 ± 0.42*
CAL (mm)									
Q-SRP	5.35 ± 0.05	4.44 ± 0.09	4.33 ± 0.09	3.21 ± 0.23	3.86 ± 0.15	0.91 ± 0.05*	1.01 ± 0.05*	2.13 ± 0.20*	1.48 ± 0.17*
FMD	5.38 ± 0.01	4.55 ± 0.02	4.47 ± 0.02	3.67 ± 0.09	3.80 ± 0.04	0.83 ± 0.02*	0.90 ± 0.01*	1.71 ± 0.08*	1.58 ± 0.04*
FM-SRP	5.76 ± 0.51	4.92 ± 0.60	4.88 ± 0.71	2.52 ± 1.25	4.44 ± 0.86	0.84 ± 0.24*	0.88 ± 0.29*	3.24 ± 0.98*§‡	1.31 ± 0.52*
BOP (%)									
Q-SRP	48.0 ± 2.0	21.0 ± 4.0	19.0 ± 2.0	17.0 ± 3.0	22.0 ± 2.0	27.0 ± 4.0*	29.0 ± 2.0*	31.0 ± 2.0*	26.0 ± 4.0*
FMD	51.0 ± 1.0	24.0 ± 1.0	19.0 ± 0.0	18.0 ± 1.0	20.0 ± 1.0	27.0 ± 2.0*	32.0 ± 1.0*	33.0 ± 1.0*	32.0 ± 1.0*
FM-SRP	46.0 ± 4.0	15.0 ± 3.0	7.0 ± 4.0	8.0 ± 3.0	18.0 ± 5.0	31.0 ± 6.0*	39.0 ± 5.0*§‡	38.0 ± 3.0*§‡	28.0 ± 7.0*
PII									
Q-SRP	34.0 ± 2.0	34.0 ± 1.0	28.0 ± 3.0	23.0 ± 4.0	33.0 ± 1.0	101.0 ± 5.0†	83.0 ± 8.0*†	69.0 ± 11.0*	99.0 ± 8.0
FMD	32.0 ± 0.0	30.0 ± 1.0	31.0 ± 1.0	25.0 ± 2.0	31.0 ± 1.0	94.0 ± 4.0*	95.0 ± 3.0*	78.0 ± 4.0*	96.0 ± 3.0*
FM-SRP	31.0 ± 12.0	39.0 ± 14.0	27.0 ± 7.0	10.0 ± 6.0	60.0 ± 27.0	127.0 ± 18.0*§‡	94.0 ± 19.0	42.0 ± 33.0*§‡	198.0 ± 49.0*§‡

*Significant ($p \leqslant 0.01$) differences of the difference to baseline (paired *t*-test).
†Significant differences between FM-SRP and Q-SRP (*F*-test of the ANOVA analysis).
‡Significant differences between FM-SRP and FMD (*F*-test of the ANOVA analysis).
§Significant differences between Q-SRP and FMD (*F*-test of the ANOVA analysis).
Q-SRP, quadrant scaling and root planing; FMD, full-mouth disinfection; FM-SRP, full-mouth scaling and root planing; PD, probing depth; CAL, clinical attachment level; BOP, bleeding on probing; PII, plaque index.

ventional staged debridement in patients with chronic periodontitis (Lang et al. 2008).

Another systematic review that compared full-mouth scaling with or without the use of antiseptics and quadrant scaling found only minor differences between the treatment strategies for adults with chronic periodontitis (Eberhard et al. 2008).

Group differences regarding the analysis of the microbiota were not found in our study. However, the bacteria could be reduced in every group although this reduction was only significant for *P. intermedia* in the FMD group 8 months after treatment. Our microbiological findings are in accordance to other studies showing no significant group differences for the bacterial load after 6 months either with conventional or with full-mouth treatment (Apatzidou et al. 2000, Jervøe-Storm et al. 2007b). Another study could find greater reductions of the bacterial counts only after 1 and 2 months with full-mouth treatment with and without the adjunctive use of chlorhexidine (Quirynen et al. 2000). However, at the end of the 8-month study, there were also no statistical significant differences between full-mouth treatment and quadrant-wise scaling and root planing.

Still the comparison of the studies is critical. The difference between the studies can be found in the treatment protocol. The dosage of chlorhexidine, the intervals between the quadrant-wise therapy, the oral hygiene instructions, the recall-intervals and the severity of disease were different. In addition, in some studies the PDs were recorded after the treatment to avoid interference due to calculus (Bollen et al. 1998, Mongardini et al. 1999, Quirynen et al. 2000). In another study, persisting pockets that had a PD $\geqslant$5 mm were re-instrumentated with ultrasonic scalers (Wennström et al. 2005). In a further study the group that underwent quadrant-wise scaling and root planing did not clean inter-dentally in the non-treated quadrants during the active phase of treatment in comparison with the other groups (Quirynen et al. 2006).

Comparison of the microbiological analysis in different studies shows that different sampling methods were applied (subgingivally, saliva, tongue, mucosa, etc.), the methods used for the analysis were not comparable (dark field microscopy, culture, PCR) or different bacteria were evaluated. For instance, in

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Table 5. Selected-site analysis (mean ± SD), deep pockets of single- and multi-rooted teeth (PD ⩾ 7 mm)

	Baseline	1 month	2 months	4 months	8 months	Baseline – 1 month (mm)	Baseline – 2 months (mm)	Baseline – 4 months (mm)	Baseline – 8 months (mm)
PD (mm)									
Q-SRP	7.78 ± 0.11	6.37 ± 0.37	5.86 ± 0.44	4.22 ± 1.12	4.33 ± 0.57	1.41 ± 0.26*	1.92 ± 0.33*	3.56 ± 1.01*	3.45 ± 0.49*
FMD	7.82 ± 0.03	6.47 ± 0.10	6.14 ± 0.07	5.17 ± 0.15	4.51 ± 0.16	1.36 ± 0.09*	1.68 ± 0.07*	2.65 ± 0.16*	3.31 ± 0.15*
FM-SRP	7.51 ± 0.02	5.58 ± 0.16	4.79 ± 0.40	3.21 ± 1.27	4.03 ± 0.89	1.93 ± 0.18*†‡	2.72 ± 0.42*†‡	4.30 ± 1.25‡	3.48 ± 0.90
CAL (mm)									
Q-SRP	8.45 ± 0.04	7.39 ± 0.20	6.98 ± 0.22	5.09 ± 0.89	5.11 ± 0.31	1.06 ± 0.19*	1.47 ± 0.20*	3.36 ± 0.87*	3.34 ± 0.30*
FMD	8.33 ± 0.07	7.28 ± 0.17	6.97 ± 0.13	5.81 ± 0.08	5.16 ± 0.15	1.05 ± 0.11*	1.37 ± 0.08*	2.52 ± 0.14*	3.18 ± 0.16*
FM-SRP	8.73 ± 0.38	7.38 ± 0.31	6.84 ± 0.19	5.24 ± 2.07	6.07 ± 1.34	1.35 ± 0.10*†‡	1.90 ± 0.26*†‡	3.50 ± 1.70	2.67 ± 1.10
BOP (%)									
Q-SRP	65.0 ± 6.0	43.0 ± 10.0	29.0 ± 7.0	28.0 ± 9.0	27.0 ± 8.0	22.0 ± 12.0	35.0 ± 6.0	36.0 ± 9.0	38.0 ± 13.0
FMD	68.0 ± 2.0	48.0 ± 3.0	35.0 ± 1.0	37.0 ± 1.0	28.0 ± 1.0	20.0 ± 5.0	33.0 ± 2.0	31.0 ± 1.0	40.0 ± 3.0
FM-SRP	67.0 ± 7.0	24.0 ± 5.0	19.0 ± 7.0	28.0 ± 11.0	19.0 ± 4.0	43.0 ± 9.0†‡	47.0 ± 11.0†‡	38.0 ± 10.0	48.0 ± 10.0
PII (%)									
Q-SRP	39.0 ± 3.0	32.0 ± 3.0	17.0 ± 7.0	20.0 ± 9.0	40.0 ± 5.0	83.0 ± 10.0	44.0 ± 16.0*§	50.0 ± 20.0*§	104.0 ± 70.0
FMD	35.0 ± 3.0	27.0 ± 2.0	21.0 ± 1.0	25.0 ± 2.0	39.0 ± 4.0	78.0 ± 7.0*	61.0 ± 5.0*	73.0 ± 3.0*	113.0 ± 3.0*
FM-SRP	53.0 ± 11.0	38.0 ± 1.0	18.0 ± 3.0	14.0 ± 6.0	51.0 ± 15.0	74.0 ± 25.0‡	34.0 ± 5.0‡	27.0 ± 9.0‡	96.0 ± 19.0

*Significant ($p \leqslant 0.01$) differences of the difference to baseline (paired *t*-test).
†Significant differences between FM-SRP and Q-SRP (*F*-test of the ANOVA analysis).
‡Significant differences between FM-SRP and FMD (*F*-test of the ANOVA analysis).
§Significant differences between Q-SRP and FMD (*F*-test of the ANOVA analysis).
Q-SRP, quadrant scaling and root planing; FMD, full-mouth disinfection; FM-SRP, full-mouth scaling and root planing; PD, probing depth; CAL, clinical attachment level; BOP, bleeding on probing; PII, plaque index.

some studies bacteria were only collected either subgingivally (Bollen et al. 1996, Apatzidou et al. 2000, Jervøe-Storm et al. 2007b) or from the saliva (Quirynen et al. 2000, Koshy et al. 2005). One study sampled bacteria also on the tongue and the mucosa (Quirynen et al. 2000). Collection of the samples was performed either by paper points (Bollen et al. 1996, Quirynen et al. 2000, Koshy et al. 2005, Jervøe-Storm et al. 2007b) or with curettes (Apatzidou et al. 2000). In this study, subgingival samples were collected with paperpoints as this technique seems to be suitable for microbiological diagnostics (Jervøe-Storm et al. 2007a). We applied a pooled sampling strategy although we know that differences in subgingival sampling techniques exist when comparing pooled samples *versus* single site sampling. This is certainly a limitation of the present study mainly when comparing the microbiological results from the Q-SRP group with the other two groups. This confounding factor may be taken into consideration when evaluating the presented results.

Detection of periodontopathogens depends on the method applied. Results from studies applying culture and differential phase-contrast microscopy (Bollen et al. 1996, Quirynen et al. 2000) to detect microorganisms are difficult to interpret as the subgingival microbial diversity observed in periodontal disease can be greatly underestimated by cultivation because many microorganisms cannot be cultivated by standard techniques. Other studies used either endpoint PCR (Apatzidou et al. 2000, Koshy et al. 2005) or real-time PCR (Jervøe-Storm et al. 2007b) which offer a higher sensitivity in comparison with conventional culture methods. In this study we applied a real-time PCR assay in order to quantify the bacterial load present in the collected sample as well as the quantification of specific periodontopathogens. With this method it was possible to follow the change of the bacterial load in all three treatment groups during the 8 months study period. Taking into consideration that the amount of microorganisms in periodontal sites might be an important determinant for the development of the disease, the main difference between periodontal disease and healthy subjects may not be the prevalence but the amount of putative pathogens present. In this sense we could show that independent of the treatment modality

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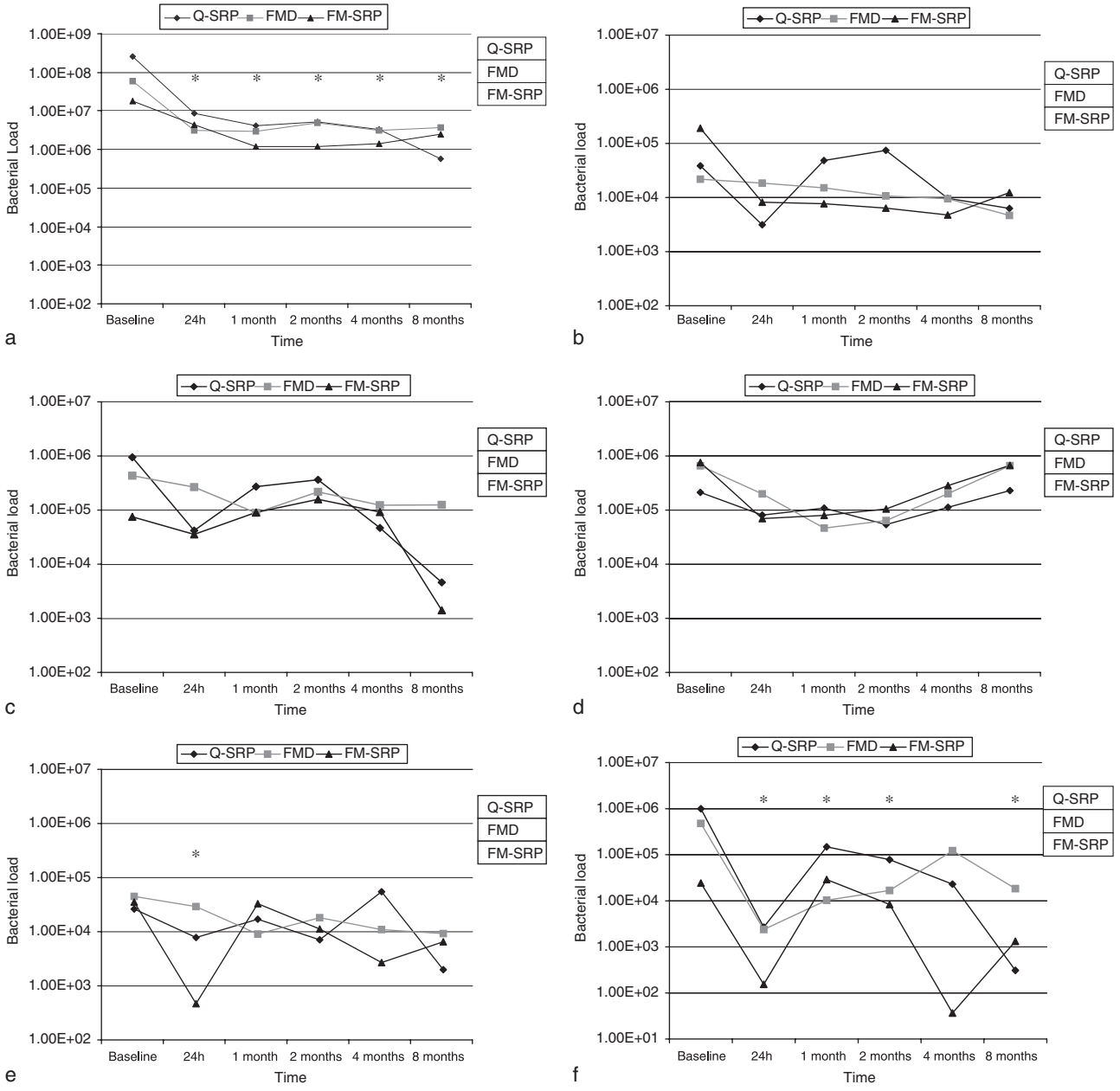

Fig. 1. Bacterial load of (a) total bacteria, (b) *Aggregatibacter actinomycetemcomitans*, (c) *Porphyromonas gingivalis*, (d) *Parvimonas micra*, (e) *Dialister pneumosintes* and (f) *Prevotella intermedia*.

Table 6. Correlations between clinical and microbiological parameters 8 months after treatment

	Eu	A.a.	P.g.	P.m.	D.p.	P.i.
Q-SRP ($n = 6$)						
PD	0.316	0.462	0.449	0.223	− 0.412	0.210
CAL	0.15	0.487	0.328	0.192	− 0.201	0.60
BOP	0.336	0.337	0.514	0.301	− 0.479	0.136
FMD ($n = 8$)						
PD	0.275	− 0.354	0.14	0.1	0.118	− 0.351
CAL	0.145	− 0.597	− 0.008	0.198	− 0.155	− 0.601
BOP	0.407	0.414	0.216	− 0.013	0.501	0.132
FM-SRP ($n = 7$)						
PD	0.352	0.818*	0.454	0.755*	0.382	0.335
CAL	0.363	0.304	0.58	0.525	− 0.112	0.885*
BOP	0.521	− 0.141	0.053	0.277	0.082	0.604

*Significant positive correlations (Spearman correlation).

Eu, Eubacteria (total bacteria); A.a., *Aggregatibacter actinomycetemcomitans*; P.g., *Porphyromonas gingivalis*; P.m., *Parvimonas micra*; D.p., *Dialister pneumosintes*; P.i., *Prevotella intermedia*.

applied, the whole microbiota decreased throughout the study.

Conclusion

The present study shows that all three treatment modalities lead to an improvement of the clinical parameters without significant group differences after 8 months. In all groups the amount of bacteria could be reduced. Considering these results the ''one-stage full-mouth disinfection'' by chlorhexidine implies no clinical and microbiological advantages towards a scaling and root planing

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in 1 day or a quadrant-wise scaling and root planing.

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Clinical Relevance

Scientific rationale for the study: To prevent re-infection of treated sites and therefore improve clinical outcomes of periodontal therapy alternatives for quadrant-wise scaling and root planing had been introduced. However, controversial results were reported.

Principle findings: Clinical and microbiological improvements could be achieved with quadrant-wise scaling and root planing as well as with treatment within 24 h with or without chlorhexidine.

Practical implication: Additional antisepsis with chlorhexidine is not necessary in infection control of patients with chronic periodontitis. All three treatment modalities improve the periodontal status.

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