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Benefit of "one-stage full-mouth disinfection" is explained by disinfection and root planing within 24 hours: a randomized controlled trial

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Abstract

Objectives: The beneficial effects of the one-stage, full-mouth disinfection remain controversial in the scientific literature. This might be due to the fact that an entire mouth disinfection with the use of antiseptics has been confused with a full-mouth scaling and root planing. This parallel, single blind RCT study aimed to compare several full-mouth treatment strategies with each other.

Material and methods: Seventy-one patients with moderate periodontitis were randomly allocated to one of the following treatment strategies: scaling and root planing, quadrant by quadrant, at two-week intervals (negative control, NC), full-mouth scaling and root planing within 2 consecutive days (FRP), or three one-stage, full-mouth disinfection (FM) protocols within 2 consecutive days applying antiseptics to all intra-oral niches for periopathogens using as antiseptics: chlorhexidine (FMCHX) for 2 months, amine fluoride/stannous fluoride for 2 months (FMF), or chlorhexidine for 2 months followed by amine fluoride/stannous fluoride for another 6 months (FMCHX+F). At baseline and after 2, 4, and 8 a series of periodontal parameters were recorded.

Results: All treatment strategies resulted in significant ($p < 0.05$) improvements of all clinical parameters over the entire duration of the study. Inter-treatment differences were often encountered. The NC group nearly always showed significant smaller improvements than the two CHX groups. The differences between the FRP or FM groups, and the two CHX groups only sporadically reached a statistical significance.

Conclusion: These observations indicate that the benefits of the ''OSFMD'' protocol are partially due to the use of the antiseptics and partially to the completion of the therapy in a short time.

Key words: antiseptics; biofilm; disinfection; infection; periodontitis; periodontal therapy; translocation

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Periodontal destruction primarily develops when the microbial load within a periodontal pocket overrules the local and systemic host defence mechanisms. Such an imbalance can result from: an a-specific increase in the total amount of bacteria, an outgrowth/overgrowth of pathogenic species above a certain threshold level, and/or a reduction in the efficiency of the immune response. The latter can be explained by both hereditary (Kinane & Hart 2003) and environmental factors such as bad oral hygiene, smoking, immunosuppressive medication, stress, etc.

Actinobacillus actinomycetemcomitans, *Tanneralla forsythia* and *Porphyromonas gingivalis* are considered key periopathogens, but species such as *Prevotella intermedia*, *Campylobacter rectus*, *Peptostreptococcus micros*, *Fusobacterium nucleatum*, *Eubacterium nodatum*, *Streptococcus intermedius* and spirochetes are also linked with periodontal destruction (Slots & Rams 1991,

Socransky & Haffajee 1992, Wolff et al. 1994, American Academy of Periodontology 1996). Most of these species are not only members of the subgingival flora, but also colonize the mucosae, the tongue and the tonsils and are commonly found in saliva (Danser et al. 1994, 1996, Petit et al. 1994, von Troil-Linden et al. 1996, Beikler et al. 2004).

As with the exception of anti-inflammatory medications, the susceptibility of the host cannot presently be modulated at a clinical level, periodontal therapy is mainly focused on the reduction/elimination of periopathogens in combination with the re-establishment, often by surgical pocket elimination, of a more suitable environment (less anaerobic) for a beneficial microbiota. Several studies indeed indicated that the presence of the above-mentioned periopathogens (persisting or re-established after treatment) was associated with a negative clinical outcome of periodontal treatment (Renvert et al. 1996, 1998, Haffajee et al. 1997, Socransky et al. 1998, 2002, Cugini et al. 2000, Socransky & Haffajee 2002).

After mechanical debridement the subgingival microbial load is reduced a thousand times (Goodson et al. 1991, Maiden et al. 1991). However within 1 week the periodontal pockets are already re-colonized by the initial number of bacteria, fortunately with a less pathogenic composition (Harper & Robinson 1987, Wade et al. 1992, Haffajee & Socransky 2005). The origin of these recurrent bacteria is still a matter of debate. They can originate from multiplication of bacteria remaining within the pocket (Petersilka et al. 2002), or within the junctional or pocket epithelium (Lamont & Yilmaz 2002) and/or the dentinal tubules (Adriaens et al. 1988, Giuliana et al. 1997). The impact of the microbiota in the supragingival area on this early subgingival re-colonization was considered negligible. The availability of two-stage implants allowed one to investigate how a sterile abutment surface, inserted in a gingival wound created on top of an endosseous implant, becomes colonized by bacteria only from the supragingival area. A recent study revealed that these ''pristine'' pockets show a microbiota within 1 week with a composition nearly identical to the one in the existing neighbouring periodontal pockets (Quirynen et al. 2005). This indicates that, even when only a supragingival origin is available for subgingival colonization, it still occurs fast. The role of the supragingival flora on the subgingival (re)colonization was so far underestimated.

In this perspective, the one-stage, full-mouth disinfection (OSFMD) was proposed by Quirynen et al. (1995), aiming at eradication, or at least suppression, of periopathogens in a very short time span from all oropharyngeal habitats (mucous membranes, tongue, tonsils, saliva). The one-stage, full-mouth approach aimed to prevent/retard a cross-contamination of the treated periodontal pockets by bacteria from untreated habitats. Several prospective RCT studies illustrated the benefit of this new treatment strategy, from both a clinical and a microbiological point of view (Quirynen et al. 1995, 1999, Bollen et al. 1996, 1998, Vandekerckhove et al. 1996, Mongardini et al. 1999, De Soete et al. 2001).

Recently, several papers evaluated a similar approach, and partially failed to prove significant differences when compared with a quadrant by quadrant therapy (Apatzidou & Kinane 2004, Apatzidou et al. 2004, Koshy et al. 2005, Wennström et al. 2005, Jervoe-Storm et al. 2006). The latter can be explained by several modifications in the treatment strategy (Quirynen et al. 2006). In these studies, either no (Apatzidou & Kinane 2004, Apatzidou et al. 2004, Wennstrom et al. 2005) or a weak antiseptic (Koshy et al. 2005) was used, rendering disinfection less effective. Furthermore, most patients suffered only from moderate periodontitis, and in some protocols oral hygiene instructions had been given before the start of the therapy so that the chance for cross-contamination was reduced.

The aim of the present study was to evaluate the relative role of antiseptics and of the timing in the ''one-stage, full-mouth'' disinfection protocol by comparing different clinical protocols: with *versus* without antiseptics (chlorhexidine 0.2% or amine fluoride/stannous fluoride, the latter being slightly inferior in antibacterial activity; Netuschil et al. 1995, Auschill et al. 2005, but with less side effects, Brecx et al. 1993) and short *versus* long time gap between debridement of four quadrants. In contrast to previous studies from our centre (involving very severe periodontitis), this study enrolled primarily patients with moderate periodontitis (pockets of 5–7 mm). This study should again be considered as a ''proof of principle'' experiment, because in the negative control (NC) group a long time interval between scaling and root planing of the different quadrants was allowed, and because in this group patients were instructed not to clean inter-dentally in the non-treated quadrants (all this to further increase the chances for cross contamination).

Materials and Methods

This trial was designed as a randomized-controlled, single-masked and parallel-group study of 8 months duration. Approval of the study protocol by the Clinical Trials Committee of the University Hospital was obtained, and all participants signed an informed consent before the start of the study.

Patient sample

Seventy-one consecutive Caucasian volunteers (from 30 to 75 years of age; mean 48; 31 females; 18 smokers) were recruited for this prospective study following a screening examination including full-mouth probing and radiographic examination. They consulted, or were referred to the Department of Periodontology of the University Hospital in Leuven for treatment of chronic periodontitis. All patients were in good general health; no pregnant females were allowed to participate in this study. The diagnosis was made on the basis of age of onset (dental history), the number of teeth involved, and severity of the destruction in relation to the age (Table 1). The following criteria were used:

Inclusion criteria:

- age 30 to 75 years,
- a minimum of 18 teeth,
- at least two multi-rooted and/or two single-rooted teeth in the first quadrant, with at least six sites having a probing depth of $\geqslant$6 mm,
- radiographic evidence of moderate bone loss ($\geqslant$25% the root length),

Exclusion criteria:

- subgingival instrumentation within 12 months before baseline examination,
- use of antimicrobial agents 4 months before the study,
- compromised medical conditions requiring prophylactic antibiotic coverage,

Table 1. Treatment strategy in different intra-oral niches for each group

Niche	Tool	NC*	FRp†	FMCHX‡	FMF§	FMCHX+F¶
Chairside						
Pockets	Root planing	1q/14 day‖	4q/24 h**	id	id	id
	Subgingival irrigation CHX 1% gel††	No	No	Yes	Yes	Yes
Tongue	CHX 1% gel‡‡	No	No	Yes	Yes	Yes
Saliva and mucosae	CHX 0.2% rinse§§	No	No	Yes	Yes	Yes
Home care during first 2 months						
Oral hygiene	Tongue and teeth	Optimal mechanical cleaning				
	Mouthrinse 2 × 10 ml/day	No	No	CHX 0.2%§§	AmF/SnF_2¶¶	CHX 0.2%§§
Home care during following 6 months						
Oral hygiene	Tongue and teeth	Optimal mechanical cleaning				
	Mouthrinse 2 × 10 ml/day	No	No	No	No	AmF/SnF_2¶¶
During entire period: no additional subgingival instrumentation						

*Negative control group (NC, $n = 15$): scaling and root planing (quadrant by quadrant) at a 2 week interval (thus 6 weeks between first and last quadrant) without adjunctive products.
†Control group (FRP, $n = 14$): one-stage, full-mouth root planing without the use of adjunctive products.
‡One-stage full-mouth disinfection followed by the use of chlorhexidine 0.2% (Corsodyl®, GlaxoSmithKline) for 2 months (CHX, $n = 14$).
§One-stage, full-mouth disinfection followed by the use of AmF/SnF_2 (Meridol mouthrinse®, GABA International AG) for 2 months (F, $n = 14$).
¶One-stage, full-mouth disinfection followed by the use of chlorhexidine for 2 months and AmF/SnF_2 for another 6 months (CHX+F, $n = 14$).
‖One quadrant is root planed per session, with a 14-day interval.
**Four quadrants are root planed within 24 h.
††Subgingival irrigation of all pockets with a 1 % chlorhexidine gel (Corsodyl® gel, GlaxoSmithKline, Genval, Belgium) three times within 10 min.
‡‡Brushing tongue for 1 min. with a 1% chlorhexidine gel (Corsodyl® gel, GlaxoSmithKline).
§§Rinsing of mouth with 10 ml chlorhexidine 0.2% mouthrinse (Corsodyl®, GlaxoSmithKline) twice for 1 min.
¶¶125 p.p.m. aminefluoride and 125 p.p.m. stannous fluoride mouthrinse (Meridol mouthrinse®, GABA International AG.

- ongoing drug therapy that might affect the clinical symptoms of periodontitis.

Experimental design

A clinician who was informed about the baseline clinical data (but not about the content of the treatment strategies) randomly allocated (via a random-number table) the consecutive participants (if fulfilling criteria) to one of the following groups (Table 1):

- a NC group (NC, $n = 15$): scaling and root planing (quadrant by quadrant, starting with first quadrant, followed at 2-week intervals by second, third and fourth quadrant, respectively; thus 6 weeks between first and last quadrant), without adjunctive products;
- a control group (FRp, $n = 14$): full-mouth root planing (in 2 consecutive days) without the use of adjunctive products;
- one of the three positive control groups ($n = 14$ per group): including a OSFMD (Quirynen et al. 1995) followed by the use of different antiseptic mouth rinses: chlorhexidine 0.2% (Corsodyl®, GlaxoSmithKline, Genval, Belgium) for 2 months (FMCHX), AmF/SnF_2 (Meridol mouthrinse®, GABA International AG, Münchenstein, Switzerland) for 2 months (FMF), or chlorhexidine 0.2% (Corsodyl®, GlaxoSmithKline) for 2 months and AmF/SnF_2 (Meridol mouthrinse®, GABA International AG) for another 6 months (FMCHX+F).

For all except the NC group, scaling and root planing were completed in two sessions within 24 h (starting with the lower jaw). Scaling and root planing was performed under local anaesthesia using periodontal hand instruments (Gracey curettes, Hu-Friedy, Chicago, IL, USA). For the three positive control groups, mechanical debridement was combined with an extensive chairside chlorhexidine application (for details see Quirynen et al. 1995). In summary, after completion of the first two quadrants, the last two quadrants, and at the 1-week follow-up visit, all pockets were irrigated with a 1% chlorhexidine gel (three times repeated within 10 min.), the tongue was brushed with the same gel for 1 min., and the mouth was rinsed two times for 1 min. with a 0.2% chlorhexidine solution. Antibiotics were never used.

All patients received standard oral hygiene instructions immediately after the first session of scaling and root planing. This included inter-dental plaque control (by toothpicks and/or inter-dental brushes), toothbrushing, and brushing of the tongue dorsum twice a day. All patients were provided with Sensodyne® toothbrushes (no. 4 medium, GlaxoSmithKline, Genval, Belgium) and Aronal® toothpaste (GABA International AG). The patients were, however, instructed to use the inter-dental devices only in those quadrants where debridement had been completed; thus in the NC group inter-dental plaque control in the last quadrant was delayed for 6 weeks, the latter in order to increase the chance for some cross contamination (as a proof-of-principle concept). Oral hygiene control and re-instruction were completed on several occasions (months 1, 2 and 4).

This experimental design aimed to investigate the hypothesis that the completion of scaling and root planing within 2 consecutive days, as well as the use of an antiseptic, both have an adjunctive effect when compared with a quadrant-by-quadrant debridement with long intervals. The sample size was based on data of previous studies (Quirynen et al. 1999) where 12 patients with chronic adult periodontitis per group was sufficient to reach statistical significance.

Periodontal parameters

The following variables (in sequential order) were recorded before subgingival debridement (baseline), and at the end

of months 2, 4 and 8 by another clinician (a periodontologist, who had been trained and tested previously for his reproducibility, correlation coefficient for repeated measurements between 0.8 and 0.9) who was not informed of the treatment strategy or the previous clinical parameters:

- extension of tooth staining on teeth in the first quadrant, assessed with the Quigley & Hein (Turesky et al. 1970) plaque index for the same teeth;
- degree of gingival inflammation along the same teeth, using the sulcus bleeding index (Muhlemann & Son 1971), with six sites per tooth (mesially, centrally and distally both buccally orally), the scores ranging from 0 to 5,
- plaque surface extension (after disclosure with a 4% aqueous erythrosin solution) assessed with the Quigley & Hein (Turesky et al. 1970) plaque index for the same teeth, and at baseline, 2 months and 8 months;
- the probing depth (PPD) and gingival recession/overgrowth (with the CEJ as reference point) along teeth in the first quadrant measured to the nearest 0.5 mm (buccally and orally of each root, and at each approximal site, both buccally and orally) by means of a Merrit B® (Hu-Friedy); tooth sites neighbouring a fresh extraction side as well as those in contact with a maxillary tuber were excluded, while molars with furcation involvement were included;
- the bleeding tendency for the same teeth evaluated 20 s after probing the depth of the pocket; the scores were 0 (absent) and 1 (present).

Information on the microbiological data can be found in an accompanying paper (De Soete et al. 2005). The scaling and root planing of the first quadrant was set as the start point for each group.

One should, however, realize that tooth staining in all groups using an antiseptic could have undermined the success of the blinding.

Statistical analysis

Probing depth and attachment level were the primary outcome variables, whereas the other parameters should be considered as secondary outcome variables. For all parameters a mean value per patient and per follow-up moment was calculated in order to maintain the patient as the statistical unit. For the plaque, staining and gingivitis index, a separate statistical analysis was performed for single- and multi-rooted teeth, respectively.

For probing values, a separate analysis was included for medium (4–5.5 mm) and deep pockets ($\geqslant$6 mm). The attachment level was calculated from both the probing depth and gingival recession/overgrowth scores, and handled in a similar way as the pocket data.

Transformations (e.g. logarithmic, square root) were carried out in order to satisfy the assumption of normally distributed error terms.

A linear mixed model was fitted taking into account the patient as a random factor and the treatment as a fixed factor (together with the experimental period if the latter was of significant importance according to Akaike's information criteria). When data were obtained over several follow-up visits, the factor time (months) was also included. Differences between treatments, and/or with baseline values were looked for via a set of pairwise comparisons, corrected for simultaneous hypothesis testing using the Tukey–Kramer method for multiple comparisons (including a Bonferonni's correction for repeated testing), for all

Table 2. Descriptive statistics of patient population ($n = 71$) sorted by treatment strategy

Strategy	*n*	Number		Age (years): mean/range
		females	smokers	
NC	15	5	5	48/31–69
FRp	14	10	3	53/31–75
FMCHX	14	4	3	47/31–61
FMF	14	6	3	46/30–57
FMCHX+F	14	6	4	47/38–57

Table 3. Changes in plaque index (modified Quigley & Hein plaque index (Turesky et al. 1970)) by treatment strategy (means and standard deviation) for single and multi-rooted teeth, respectively

Strategy	Quigley & Hein plaque index (mean and SD)			
	baseline	month 2	month 4	month 8
Single rooted				
NC	2.69 ± 0.6	1.96 ± 0.8	1.82 ± 0.6	1.67 ± 0.8
FRp	2.35 ± 0.7	1.37 ± 0.6	1.08 ± 0.7	1.26 ± 0.8
FMCHX	2.11 ± 0.7	1.20 ± 0.8	1.33 ± 0.7	1.02 ± 0.5
FMF	2.22 ± 0.9	1.45 ± 0.9	1.24 ± 0.7	1.29 ± 0.8
FMCHX+F	2.47 ± 0.7	0.91 ± 0.7	1.11 ± 0.7	1.14 ± 0.6
Multi-rooted				
NC	3.24 ± 0.5	2.45 ± 0.6	2.25 ± 0.8	2.26 ± 0.9
FRp	2.74 ± 0.6	1.89 ± 0.4	1.48 ± 0.7	1.75 ± 0.8
FMCHX	3.02 ± 0.4	1.60 ± 0.9	1.86 ± 0.7	1.91 ± 0.6
FMF	2.96 ± 0.6	2.17 ± 0.5	2.24 ± 0.6	2.14 ± 0.7
FMCHX+F	3.08 ± 0.5	1.31 ± 0.7	1.89 ± 0.8	1.85 ± 0.6

Table 4. Changes in staining index (modified Quigley & Hein plaque index (Turesky et al. 1970)) by treatment strategy (means and standard deviation) for single and multi-rooted teeth, respectively

Strategy	Staining index (mean and SD)		
	month 2	month 4	month 8
Single rooted			
NC	0.24 ± 0.4	0.22 ± 0.4	0.30 ± 0.5
FRp	0.15 ± 0.2	0.11 ± 0.1	0.20 ± 0.4
FMCHX	0.99 ± 0.6	0.38 ± 0.4	0.40 ± 0.4
FMF	1.42 ± 0.9	0.66 ± 0.6	0.53 ± 0.6
FMCHX+F	1.77 ± 0.8	1.20 ± 0.6	1.22 ± 0.6
Multi-rooted			
NC	0.44 ± 0.6	0.36 ± 0.5	0.47 ± 0.7
FRp	0.44 ± 0.4	0.26 ± 0.3	0.24 ± 0.4
FMCHX	1.16 ± 0.9	0.38 ± 0.3	0.59 ± 0.4
FMF	1.56 ± 0.7	0.70 ± 0.6	0.46 ± 0.4
FMCHX+F	1.86 ± 0.8	1.31 ± 0.7	1.28 ± 0.9

Table 5. Changes in gingivitis index (Mühlemann & Son 1971) by treatment strategy (means and standard deviation) for single and multi-rooted teeth, respectively

Strategy	Sulcus bleeding index (mean and SD)			
	baseline	month 2	month 4	month 8
Single rooted				
NC	0.45 ± 0.5	0.18 ± 0.2	0.07 ± 0.1	0.08 ± 0.1
FRp	0.52 ± 0.6	0.08 ± 0.1	0.07 ± 0.1	0.07 ± 0.1
FMCHX	0.46 ± 0.8	0.07 ± 0.1	0.07 ± 0.1	0.05 ± 0.1
FMF	0.36 ± 0.3	0.10 ± 0.1	0.05 ± 0.1	0.14 ± 0.2
FMCHX+F	0.26 ± 0.4	0.03 ± 0.1	0.10 ± 0.2	0.06 ± 0.1
Multi-rooted				
NC	0.55 ± 0.5	0.28 ± 0.4	0.13 ± 0.2	0.12 ± 0.2
FRp	0.64 ± 0.5	0.11 ± 0.1	0.08 ± 0.1	0.22 ± 0.2
FMCHX	0.53 ± 0.7	0.10 ± 0.1	0.08 ± 0.1	0.13 ± 0.1
FMF	0.65 ± 0.6	0.14 ± 0.2	0.18 ± 0.3	0.27 ± 0.3
FMCHX+F	0.54 ± 0.5	0.11 ± 0.2	0.09 ± 0.1	0.09 ± 0.1

Table 6. Changes in probing depth by treatment strategy (means and standard deviation) for single and multi-rooted teeth, and medium and moderate pockets, respectively

Strategy	Pocket probing depth (mean and SD)					
	medium pockets			moderate pockets		
	month 0	month 2	month 8	month 0	month 2	month 8
Single rooted						
NC	4.8 ± 0.2	3.5 ± 0.4	3.5 ± 0.5	7.2 ± 0.5	5.0 ± 0.9	4.9 ± 0.9
FRp	4.9 ± 0.3	3.5 ± 0.6	3.5 ± 0.5	6.8 ± 0.3	4.4 ± 0.7	4.3 ± 0.8
FMCHX	4.9 ± 0.2	3.2 ± 0.4	3.1 ± 0.4	6.9 ± 0.5	4.3 ± 0.8	4.3 ± 0.7
FMF	4.7 ± 0.2	3.3 ± 0.3	3.3 ± 0.4	6.9 ± 0.6	4.5 ± 0.8	4.5 ± 0.7
FMCHX+F	4.9 ± 0.2	3.3 ± 0.5	3.2 ± 0.4	7.1 ± 0.6	4.4 ± 0.9	4.3 ± 0.9
Multi-rooted						
NC	4.7 ± 0.2	3.8 ± 0.5	3.7 ± 0.6	7.3 ± 0.7	5.1 ± 0.9	5.0 ± 0.9
FRp	5.2 ± 0.2	3.8 ± 0.4	3.7 ± 0.4	7.3 ± 0.5	4.7 ± 0.8	4.7 ± 0.7
FMCHX	4.9 ± 0.4	3.3 ± 0.5	3.4 ± 0.7	7.3 ± 0.6	4.5 ± 0.9	4.6 ± 0.7
FMF	4.7 ± 0.3	3.5 ± 0.5	3.3 ± 0.4	7.0 ± 0.9	4.8 ± 1.0	4.7 ± 1.0
FMCHX+F	4.6 ± 0.3	2.9 ± 0.6	3.0 ± 0.7	7.5 ± 0.7	4.5 ± 0.8	4.4 ± 0.9

variables except the gingivitis index for which a sign-rank test was used. The α level for significance was set at 0.05.

Results

The characteristics of the patient sample are summarized in Table 2. A total of 85 subjects were initially enrolled in the study but only 71 completed the entire 8-month follow-up. Fourteen patients dropped out (at different follow-up visits, especially during winter time), mostly because of the intake of antibiotics for a non-dental-related infection or due to non-compliance. The number of dropouts was similar for the five groups.

This report only included data from the 71 patients who completed the 8-month study. The average number of sites in the first quadrant (reference quadrant) showing a baseline PPD >4 mm ranged from 35% to 58%. All groups were relatively comparable with respect to age, smoking and degree of periodontal destruction (Table 2).

Plaque, staining and gingivitis indices

At baseline, no significant differences in plaque scores could be observed between the five treatment strategies ($p>0.15$), either for single- or for multi-rooted teeth (Table 3). In comparison with baseline, all treatment strategies resulted in a significant reduction in plaque score, and this for all follow-up visits ($p<0.001$). The mean plaque index remained, however, relatively high, with 1.2 for single-rooted and 1.5 for multi-rooted teeth, respectively. Between treatment strategies, small differences were recorded. At month 2, a significant additional improvement could be seen ($p\leqslant 0.008$) for the FMCHX and FMCHX+F group when compared with the NC group (and to the FMF group for multi-rooted teeth only). At month 4, still an inter-treatment difference was still visible ($p=0.03$), now with the FRp and FMCHX+F groups (single-rooted teeth only) showing lower values than the NC group. At month 8 no inter-group differences remained ($p>0.18$).

The degree of tooth staining (Table 4) showed a significant variation between treatment strategies for all follow-up visits ($p<0.0001$). At month 2, the three groups using a mouth rinse showed significantly ($p<0.05$) more staining than the NC or FRp group. Strangely enough, between the two groups rinsing with CHX, a significant difference was also recorded ($p<0.05$). At months 4 and 8, only the FMCHX+F group (the only group using a rinse) showed significantly more staining than all the other groups.

At baseline, no significant differences in gingivitis scores could be observed between the five treatment strategies ($p>0.80$), either for single- or for multi-rooted teeth (Table 5). In comparison with baseline, all treatment strategies resulted in a significant reduction in gingivitis score, and this for all follow-up visits ($p<0.001$). Between treatment strategies, only minor differences were registered ($p=0.05$). Only at month 2, the NC group showed slightly higher values than the other groups ($p<0.02$).

Pocket probing depth reduction and attachment level changes

At baseline, no inter-group differences in probing depth or attachment loss were recorded, either for single- or for multi-rooted teeth ($p>0.5$). All therapies resulted in significant reductions in probing depth (Table 6) for both single- and multi-rooted teeth up to month 8 ($p<0.001$). This reduction ranged from 1.2 to 1.7 mm in medium pockets (4–5.5 mm), and from 2.2 to 2.9 mm in deeper pockets ($\geqslant 6$ mm), respectively.

The CHX groups (FMCHX and FMCHX+F) always presented more pocket depth reductions ($p<0.05$) than the NC (at months 2 and 8, especially for single-rooted teeth and to a lower extent for multi-rooted teeth). The improvements in the FRp and FMF group were slightly better than for the NC group (borderline level of significance, $p\leqslant 0.10$). The improvements in the FRp and FMF groups were, on the other hand, smaller than those for both CHX groups, but the difference never reached statistical significance. Between

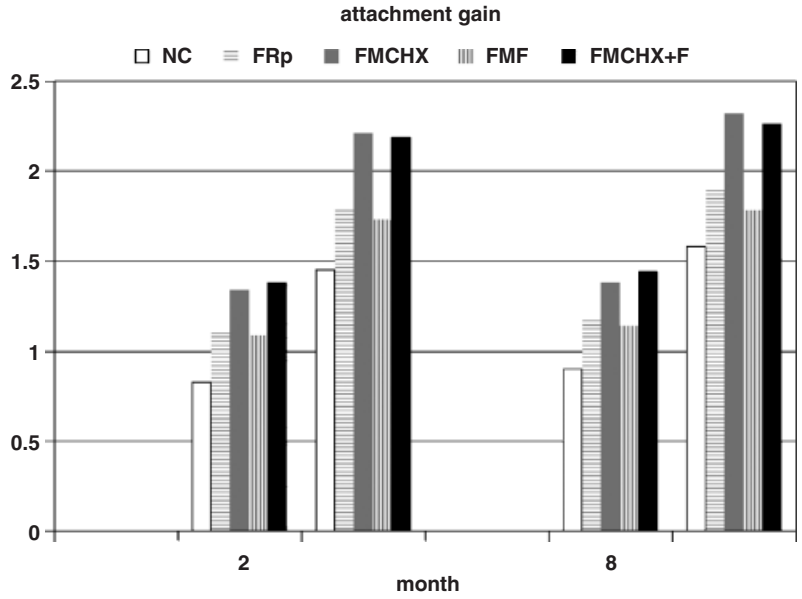

Fig. 1. Mean attachment level changes for five treatment strategies (different filling pattern) registered at months 2 and 8, in comparison with baseline values, for initially medium (first set) and deep pockets, respectively.

Table 7. Changes in proportion of bleeding sites after probing sorted by treatment strategy (means and standard deviation) for single and multi-rooted teeth, respectively

Strategy	Bleeding upon probing (mean and SD)					
	medium pockets			moderate pockets		
	month 0	month 2	month 8	month 0	month 2	month 8
Single rooted						
NC	0.84 ± 0.2	0.40 ± 0.2	0.34 ± 0.2	0.90 ± 0.2	0.45 ± 0.4	0.51 ± 0.3
FRp	0.89 ± 0.2	0.53 ± 0.2	0.49 ± 0.2	0.94 ± 0.1	0.67 ± 0.2	0.59 ± 0.2
FMCHX	0.79 ± 0.2	0.39 ± 0.3	0.28 ± 0.2	0.94 ± 0.1	0.47 ± 0.3	0.41 ± 0.2
FMF	0.81 ± 0.2	0.45 ± 0.2	0.40 ± 0.2	0.93 ± 0.1	0.66 ± 0.3	0.60 ± 0.2
FMCHX+F	0.82 ± 0.2	0.33 ± 0.2	0.26 ± 0.2	0.94 ± 0.1	0.50 ± 0.2	0.38 ± 0.3
Multi rooted						
NC	0.79 ± 0.3	0.54 ± 0.4	0.55 ± 0.3	0.90 ± 0.2	0.55 ± 0.4	0.51 ± 0.3
FRp	0.85 ± 0.4	0.65 ± 0.3	0.50 ± 0.4	0.90 ± 0.2	0.66 ± 0.2	0.55 ± 0.3
FMCHX	0.84 ± 0.2	0.49 ± 0.4	0.39 ± 0.4	0.90 ± 0.2	0.64 ± 0.3	0.59 ± 0.2
FMF	0.80 ± 0.3	0.37 ± 0.3	0.36 ± 0.3	0.89 ± 0.2	0.68 ± 0.2	0.48 ± 0.4
FMCHX+F	0.82 ± 0.4	0.41 ± 0.3	0.38 ± 0.4	0.89 ± 0.2	0.50 ± 0.2	0.50 ± 0.2

both CHX groups, the differences were negligible.

A similar trend was observed for changes in attachment levels (Fig. 1). In general, the gain in attachment obtained in the different groups ranged from 0.9 to 1.4 mm for medium, to 1.6 to 2.3 mm for deeper pockets, respectively.

The CHX groups showed more gain in attachment, both in single- ($p \leqslant 0.02$) and ($p \leqslant 0.05$) multi-rooted teeth, when compared with the NC group (ca. 0.5 and 0.7 mm difference). The FRp and FMM groups also scored better than the NC group ($p \leqslant 0.06$ at month 2, $p \leqslant 0.10$ at month 8). In comparison with the CHX groups, however they scored inferior, but again the difference did not reach a level of significance. Between both CHX groups the differences were negligible.

Bleeding on probing

The proportion of bleeding sites (pockets $\geqslant 4$ mm) dropped after therapy for all treatment strategies ($p < 0.001$), from an overall mean of above 85% to around 45% at month 8 (Table 7). The best reductions were obtained in the CHX groups, although the differences with the other groups were only borderline significantly different. At month 8, the proportion of bleeding sites dropped to 32% and 44% for medium and deeper pockets in the CHX groups.

Discussion

This paper indicates again that a OSFMD approach (performed in 2 consecutive days), including the application of chlorhexidine to all oral habitats for periopathogens, both chairside and at home (for a period of 2 months), results in significant additional clinical improvements when compared with a standard quadrant-by-quadrant approach with longer time intervals. One should remember that also in the present study the design is intended as ''a proof of principle''; for that reason, long (2 weeks) intervals were chosen for the quadrant per quadrant treatment. The present results are in agreement with our previous findings (Quirynen et al. 1995, 1999, Bollen et al. 1996, 1998, Vandekerckhove et al. 1996, Mongardini et al. 1999, De Soete et al. 2001). The observations in this paper are further supported by the subgingival microbial changes. All except the NC group showed, up to month 8, significant ($p < 0.01$) reductions in the number of colony-forming units under anaerobic growth conditions (De Soete et al. 2005).

The present study, however, contrasts with data from our previous pilot study (Quirynen et al. 2000), as the use of a strong antiseptic in the present study was found to play a significant role. The latter is illustrated by the difference between the full-mouth scaling and root planing group (FRp) on the one hand, and both FMCHX groups on the other hand. The FRp, and eventually also the FMF group, can be seen as intermediate groups. In the FRp group all teeth were root planed in 2 consecutive days but antiseptics were not used, while in the FMF group a full-mouth disinfection had been envisaged (including the use of chlorhexidine chairside), but the efficiency of the antiseptic afterwards (home use) was not as good as the 0.2% chlorhexidine, as illustrated in Table 6. The success of the OSFMD is thus partially explained by the full-mouth debridement within 2 days, when associated with a disinfection of all niches with chlorhexidine chairside, and partially by the optimized plaque control after therapy ensured via the use of a strong antiseptic. In our pilot study

(Quirynen et al. 2000), a third group (one-stage, full-mouth scaling and root planing without further disinfection with an antiseptic) was added, as a pilot group, to an already running study. The design of this pilot study was thus not optimal and bias of the clinicians cannot be excluded. Two recent studies clearly illustrated that the microbial load in the saliva of periodontitis patients will reduce significantly after therapy, and especially that this reduction further reduces the rate of de novo, supragingival plaque formation (Dahan et al. 2004, Rowshani et al. 2004, Sekino et al. 2004). As such, the completion of the root planing in 2 consecutive days might reduce the chances for cross contamination.

The importance of optimal plaque control has been illustrated in several studies, reporting the best improvements in patients with the best plaque control (Lindhe et al. 1982, Axelsson et al. 1991, Westfelt et al. 1998, Ximenez-Fyvie et al. 2000, Checchi et al. 2002). In patients with severe periodontitis, a one-stage, full-mouth approach will automatically result in an immediate reduction of the microbial load and as such in a delayed de novo plaque formation. The use of the antiseptic will further improve this effect. This beneficial aspect has also been illustrated in several clinical trials examining the impact of repeated supragingival professional cleaning on the subgingival flora (Dahlen et al. 1992, al Yahfoufi et al. 1995, Hellstrom et al. 1996).

The data of the present study, together with previous studies from our group, seem, in a first view, partially in contrast with four recently published papers on full-mouth approaches in the treatment of periodontitis (Apatzidou & Kinane 2004, Koshy et al. 2005, Wennstrom et al. 2005, Jervoe-Storm et al. 2006). This disparity in results might be explained by major differences in treatment protocol, especially in the perspective of risks for microbial cross contamination (Quirynen et al. 2006). Differences in the use of chlorhexidine (mouth rinsing and/or disinfection of all niches), the time interval between treatment of all quadrants, the absence of oral hygiene instructions before therapy, the recall frequency and the severity of disease, and the amount of calculus before therapy could all indeed increase the chances for cross contamination. Besides our group, only one other study really envisaged an entire mouth disinfection (Koshy et al. 2005) in order to reduce the bacteria from the other intra-oral niches for periopathogens (Danser et al. 1994, 1996, Petit et al. 1994, von Troil-Linden et al. 1996, Beikler et al. 2004). In the latter paper, however, a weaker antiseptic (0.05% chlorhexidine) has been used than in the Leuven studies. The two other papers did not even use an antiseptic. Major inter-study variation can also be observed in the timing of oral hygiene instruction. In three studies (Koshy et al. 2005, Wennström et al. 2005, Jervoe-Storm et al. 2006), for example, all subjects received one or more visits of tooth brushing instructions including the use of inter-dental cleaning aids, before the start of the study, which probably reduces the chance for cross contamination. In the Leuven studies, the patients did not even clean the untreated sites, until after subgingival debridement. For the control group this means that inter-dental cleaning in the last quadrant for root planing was postponed until 6 weeks after the start of the study. The latter of course increased the chance for cross contamination in this group. During the healing phase after debridement, only our studies observed significant differences in plaque scores among the experimental groups. Significantly better scores were noted for the CHX groups. These higher plaque scores in the control groups in Leuven can at least partially be explained by the remaining plaque and calculus in the untreated sites, acting as a reservoir for the bacteria colonizing the root-planed teeth (Dahan et al. 2004, Rowshani et al. 2004).

Finally, even though often forgotten (Kinane 2005), one should realize that two of these three studies (Apatzidou & Kinane 2004, Koshy et al. 2005) showed some limited but statistically significant advantages with the full-mouth approach. Koshy et al. (2005) reported, for the full-mouth approach, a significant additional reduction in sites with pockets $\leqslant 5$ mm as well as a more dramatic reduction in bleeding upon probing. Apatzidou & Kinane (2004) observed, at the end of their study, a significant additional gain in attachment of nearly 1 mm in deep pockets of patients treated with the full-mouth protocol, but they warned that only a low number of sites were involved.

The data of the present study, when analysed in detail, however can also be seen as a confirmation of some of the above-mentioned papers from other centres. The lack of major differences between the full-mouth scaling and root planing group (FRp) without antiseptics and the NC group is a confirmation of the observations of Wennström et al. (2005), Apatzidou & Kinane (2004) and Jervoe-Storm et al. (2006), who also found only minor or no (Jervoe-Storm et al. 2006) differences between both strategies. The data of Koshy et al. (2005), applying a full-mouth disinfection protocol, but with a weak antiseptic, are comparable with our observations in the FMF group. All these observations seem to emphasize the significant role of the antiseptic during the healing after initial periodontal therapy.

Within the limitations of this study, one can conclude that the use of antiseptics, as well as the completion of the scaling and root planing sessions within a short time frame, seem to have a beneficial effect in the treatment of moderate and severe periodontitis. Especially in patients with an increased risk for cross contamination (e.g. supragingival plaque and calculus), the completion of all debridement within a short time frame can be recommended together with the use of a strong antiseptic.

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Clinical Relevance

Scientific rationale for the study: A series of studies reported on the benefits of a ''one-stage, full-mouth disinfection'' protocol in the treatment of severe periodontitis. Whether these additional improvements in relation to the traditional quadrant-by-quadrant approach were due to the use of antiseptics or the full-mouth root planing remains a matter of debate.

Principal findings: Within the limitations of this study, one can conclude that both the use of antiseptics, and the completion of the scaling and root planing sessions within a short time frame seem to have a beneficial effect, especially when the two are combined.

Practical implications: In patients with an increased risk for cross-contamination (e.g. supragingival plaque and calculus), the completion of all debridement within a short time frame together with the use of a strong antiseptic can be recommended in order to further improve healing after initial periodontal therapy.