One-stage, full-mouth disinfection: fiction or reality?

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Periodontal breakdown develops when the microbial load within a periodontal pocket overwhelms the local and systemic host defense mechanisms. Such an imbalance can occur in different situations, for example, following a specific increase in the total amount of bacteria, when an outgrowth/overgrowth of pathogenic species (above a certain threshold level) occurs and/or because of a change in the efficiency of the host response (hyper-responsiveness or hyporesponsiveness). Changes in the host response can be explained by hereditary factors (30) and by environmental factors such as poor oral hygiene and smoking. Immunosuppressive medications, stress, etc., can further impair the host defense mechanisms.

Aggregatibacter actinomycetemcomitans, *Tannerella forsythia* and *Porphyromonas gingivalis* are considered to be key periodontopathogens, but *Prevotella intermedia*, *Campylobacter rectus*, *Peptostreptococcus micros*, *Fusobacterium nucleatum*, *Eubacterium nodatum*, *Streptococcus intermedius* and spirochetes are also linked to periodontal destruction (4, 64, 65, 81). Most of these species are not only members of the subgingival flora, but also colonize the oral mucosa, the tongue and the tonsils, and are commonly found in saliva (8, 17, 18, 50, 75).

Because the susceptibility of the host cannot be modulated at a clinical level (with the possible exception of anti-inflammatory medications), periodontal therapy is primarily focused on the reduction/elimination of periodontal pathogens, in combination with the re-establishment (often by surgical pocket elimination) of a more suitable environment (less anaerobic) for beneficial microbiota. Several studies indicate that the presence of periodontal pathogens (persisting or re-established after treatment) is associated with a negative clinical outcome of periodontal treatment (14, 26, 58, 59, 68).

After mechanical debridement, the subgingival microbial load (colony-forming units/ml) decreases to 0.1% of pretreatment levels (23, 39). However, only 1 week later, the periodontal pocket has become recolonized by a similar number of bacteria, fortunately of a less pathogenic nature (27, 76). The origin of these bacteria is still a matter of debate. The multiplication of the remaining bacteria within the pocket (49), or within either the junctional or pocket epithelium (34) and/or within the dentinal tubules (1, 22), is considered to be the major cause of this subgingival recolonization.

The impact of the supragingival environment on this early subgingival recolonization process is unclear. Oral implants, however, have facilitated the investigation of the initial colonization of a pristine pocket (created by a sterile abutment to the gingiva) in an established ecosystem, with the supragingival area as the sole bacterial source. Recent studies have revealed that after only 1 week these 'pristine' pockets harbor a mature microbiota with a composition nearly identical to that of the neighboring periodontal pockets (56). Fürst et al. (21) and Salvi et al. (61) even observed periodontopathogens such as *A. actinomycetemcomitans* and *P. gingivalis* in the sulci of one-stage implants, within 30 min after implant insertion. These observations indicate that supragingival plaque also plays a significant role in the subgingival recolonization of periodontal pockets. As such, bacteria in the saliva or on the tongue, tonsils or oral mucosa can have an impact on the subgingival recolonization of pockets after periodontal therapy.

With this perspective, a one-stage, full-mouth disinfection procedure, was proposed by the research group at the Catholic University at Leuven, Belgium, as a new treatment strategy (52). The aim of the full-mouth disinfection approach was to eradicate, or at least suppress, all periodontal pathogens in a very

short time span, not only from the periodontal pockets but from the entire oropharyngeal cavity (mucous membranes, tongue, tonsils and saliva). As such, the recolonization of the treated pockets by bacteria from untreated sites / niches (called cross-contamination or intra-oral translocation) might be delayed until better healing of the pockets is achieved. The one-stage full-mouth disinfection concept consists of a combination of several thera-peutic efforts. Full-mouth scaling and root planing (the entire dentition in two visits within 24 h, i.e. two consecutive days) to reduce the number of subgin-gival pathogenic organisms (37, 44). An additional subgingival irrigation (three times, repeated within 10 min.) of all pockets with a 1% chlorhexidine gel in order to suppress the remaining bacteria (46). Ton-gue brushing by the patient with a 1% chlorhexidine gel for 1 min. to suppress the bacteria in this niche (53). Chairside mouth rinsing by the patient with a 0.2% chlorhexidine solution for 2 min. to reduce the number of bacteria in the saliva (62) and in the pharynx, including the tonsils (by gargling or via the use of a local spray), prior to and after each ses-sion of root planing. Optimal oral hygiene, supported during the first 2 months by a 0.2% chlorhexidine mouthrinse (38) to retard the recolonization of the pockets.

In this article, the Leuven studies are reviewed and analyzed together with comparable studies from other centers. Moreover, review papers on the one-stage, full-mouth concept are included and evaluated.

One-stage, full-mouth disinfection

The impact of a one-stage, full-mouth disinfection procedure (Table 1) was explored in four prospective studies (9, 10, 19, 43, 52–54, 74). The studies were designed as 'proof of principle' experiments. In the control group, the recolonization of the treated pockets was provoked by the long time-interval before completion of the debridement of all quad-rants (in total 6 weeks) and the lack of oral hygiene in the untreated quadrants. Furthermore, only patients with severe periodontitis (periodontal pockets ≥ 7 mm) and with a significant amount of supragin-gival and subgingival plaque and calculus were selected. In other words, the probability of cross-contamination was very high. In the test group, by contrast, a debridement of all periodontal pockets within 2 consecutive days, together with the extensive use of chlorhexidine in all niches, was applied with the goal of extensive reduction of the bacterial load within the oropharynx.

All four studies reported significantly greater improvements of clinical outcomes in the test group, including: a significant additional reduction in probing depth (up to 1.5 mm for single-rooted teeth and up to 1.0 mm for multirooted teeth for initial pockets ≥7 mm), a significant additional gain in clinical attachment level (up to 1.7 mm for single-rooted teeth and up to 1.5 mm for multirooted teeth for pockets initially ≥7 mm) and a significantly greater reduction in bleeding upon probing.

These clinical observations were further sup-ported by the microbiological data from these blinded studies (Table 2). The one-stage, full-mouth disinfection procedure resulted in statistically sig-nificant additional reductions in the prevalence of periodontopathogens, especially subgingivally, and to a lesser extent in the other intra-oral niches, the latter especially during the period when the pa-tients were rinsing with chlorhexidine (9, 10, 19, 52, 53).

There are several possible explanations for the reported success of this one-stage, full-mouth disin-fection protocol. All the above-mentioned studies clearly indicated that when the opportunity for intra-oral translocation of periodontopathogens was reduced, the outcome of nonsurgical periodontal therapy could be improved. The mechanism for the intra-oral translocation of the pathogenic species remains unidentified. However, saliva, in which all bacterial species can survive, seems to play an important role. The translocation of periodontal pathogens directly into a periodontal pocket through the salivary flow is, however, unlikely because the continuous outflow of crevicular fluid from the pocket makes this nearly impossible. An indirect impact via a change in the supragingival plaque that may gradually extend subgingivally seems to be a more reasonable explanation. Several studies have indeed indicated that the subgingival microbiota depends, at least partially, on the presence of supragingival plaque (16, 28, 36, 41, 80).

However, one should realize that bacteria can also be translocated subgingivally by contaminated oral hygiene aids and / or dental instruments (which can penetrate the pocket) (77, 78). Several studies reported that toothbrushes used in a daily regimen harbor a complex microbiota, including periodonto-pathogens (55), cocci, *Haemophilus* spp. and fungi (40), and *Streptococcus mutans* (55, 69), and most of these bacteria survived for 48 h or even longer on these toothbrushes.

Table 1. Overview of different clinical trials involving a one-stage, full-mouth disinfection protocol (Leuven centre, always similar protocol)

Authors	Treatment strategy	Antiseptics used in the full-mouth disinfection group			Status prior to therapy	n	Outcome comparison between strategies
		Chairside		Home			
		Subgingivally	Oral niches				
Quirynen et al. (52) Vandekerckhove et al. (74)	One-stage, full-mouth disinfection (2 days) vs. scaling and root planing per quadrant (2 weeks)	Chlorhexidine 1% irrigation	Chlorhexidine 0.2%	Chlorhexidine 0.2% 2 m	No oral hygiene instruction prior to therapy	5/5	2 months: the gingivitis index:plaque index ratio was statistically significantly lower in the full-mouth disinfection group (0.7–0.2 vs. 0.6–0.4); the probing pocket depth was statistically significantly lower in the full-mouth disinfection group (0.8 mm additional reduction). 8 months: probing pocket depth was statistically significantly lower in the full-mouth disinfection group (for pockets ≥7 mm, 0.8 and 1.2 mm additional reduction for single-rooted and multirooted teeth, respectively); bleeding upon probing reduction was similar; gingivitis in-dex:plaque index ratio was similar.
Bollen et al. (10)	One-stage, full-mouth disinfection (2 days) vs. scaling and root planing per quadrant (2 weeks)	Chlorhexidine 1% irrigation	Chlorhexidine 0.2%	Chlorhexidine 0.2% 2 m	No oral hygiene instruction prior to therapy	8/8	4 months: probing pocket depth was statistically significantly lower in the full-mouth disinfection group (for pockets ≥7 mm, 2.3 and 1.4 mm additional reduction for single-rooted and multirooted teeth, respectively; the corresponding values for 5–6 mm pockets were 0.9 and 0.7 mm additional reduction); clinical attachment level gain was statistically significantly higher in the full-mouth disinfection group; bleeding upon probing was statistically lower in the full-mouth disinfection group.
Mongardini et al. (43)	One-stage, full-mouth disinfection (2 days) vs. scaling and root planing per quadrant (2 weeks)	Chlorhexidine 1% irrigation	Chlorhexidine 0.2%	Chlorhexidine 0.2% 2 m	No oral hygiene instruction prior to therapy	20/20	8 months: probing pocket depth was statistically significantly lower in the full-mouth disinfection group of chronic adult periodontitis patients (1.8 and 1.3 mm additional reduction for single-rooted and multirooted teeth pockets ≥7 mm), respectively; corresponding values for early-onset periodontitis patients (ns): 0.7 and 0.3 mm additional reduction; clinical attachment level showed statistically significantly more gain in the full-mouth disinfection group of chronic adult periodontitis patients (1.7 and 1.5 mm additional gain for single-rooted and multirooted teeth (pockets ≥7 mm), respectively; corresponding values for early-onset periodontitis patients (ns): 0.5 and 0.2 mm additional gain; bleeding upon probing levels were statistically significantly lower in the full-mouth disinfection group (30% vs. 45% sites with bleeding upon probing); the proportion of patients with overall gain in clinical attachment level of >1.0 mm was 15/20 in the full-mouth disinfection group vs. 4/20 in the control group.

Table 1. Continued.

Authors	Treatment strategy	Antiseptics used in the full-mouth disinfection group			Status prior to therapy	n	Outcome comparison between strategies
		Chairside		Home			
		Subgingivally	Oral niches				
Quirynen et al. (57)*	One-stage, full-mouth disinfection (2 days) vs. scaling and root planing per quadrant (2 weeks)	Chlorhexidine 1% irrigation	Chlorhexidine 0.2%	Chlorhexidine 0.2% 2 m	No oral hygiene instruction prior to therapy	14 / 15	8 months: probing pocket depth was statistically significantly lower in the full-mouth disinfection group (0.3 and 0.4 mm) additional reduction for single-rooted and multirooted teeth (pockets ≥ 6 mm), respectively; the clinical attachment level showed statistically significantly more gain in the full-mouth disinfection group (0.5 and 0.7 mm) additional gain for single-rooted and multirooted teeth (pockets ≥ 6 mm), respectively; bleeding upon probing was statistically significantly lower in the full-mouth disinfection group.

Treatment strategy: one-stage, full-mouth disinfection and scaling and root planing per quadrant.
*Only two of the five arms of the study are included.
Outcome variables: gingival index, plaque index, probing pocket depth, bleeding upon probing, statistically significant, not statistically significant, clinical attachment level.

The observation that patients experiencing an increase in body temperature the evening after the second day of the one-stage, full-mouth treatment (scaling and root planing of the last two quadrants, with or without the use of chlorhexidine) showed the most impressive improvements, suggests that part of the success might be related to an increased immunologic response (e.g. a Schwartzman reaction); however, this is still speculative. Indeed, the second introduction of bacteria / lipopolysaccharides from the subgingival area into the underlying tissues (during treatment of the remaining quadrants), 24 h after the first stage of treatment could have led to a local Schwartzman reaction (a hypersensitivity reaction with a more aggressive immunologic reaction towards the agents) as has been demonstrated in animal models (2, 33).

In the above-mentioned study (54), although not designed to investigate the hyperthermic reaction after scaling, it is noteworthy that seven out of the 11 patients whose body temperature rose above 37 °C after the second day, had an overall average pocket depth reduction of ≥3.5 mm, whereas this was only the case for four of the remaining 13 patients who did not develop hyperthermia. This vaccine effect, after repeated scaling and root planing, has also been suggested in previous publications (47–49). In one study, Pawlowski et al. (48) left three teeth in one quadrant untreated, while all other teeth were scaled and root planed. The untreated sites showed a significant probing depth reduction and gain in attachment, and the number of *Treponema denticola* and *P. intermedia* species, counted in the subgingival flora of these sites, were reduced for up to 12 weeks. Also, these authors suggested that up to half of the improvements observed following scaling and root planing may be a result of factors other than the removal of plaque, calculus and irritants.

The impact of bacterial translocation from untreated to treated sites was also highlighted in two other independent studies. Nowzari et al. (45) evaluated the amount of guided tissue regeneration and membrane contamination after the treatment of mandibular posterior two-wall to three-wall defects in either a group of patients with a healthy periodontium in the remaining dentition (no pockets ≥ 5 mm, besides the study site) ($n = 20$) or a group of patients with multiple remaining periodontal pockets of ≥5 mm and numerous periodontal pathogens ($n = 22$). The periodontally healthy group showed significantly less membrane contamination when compared with the perodontally diseased group,

Table 2. Microbiological changes with different treatment strategies (data from clinical trials discussed in Tables 1 and 3)

Authors	Treatment Strategy	Outcome comparison between strategies
Quirynen et al. (52) Bollen et al. (9)	One-stage, full-mouth disinfection (2 days) vs. scaling and root planing per quadrant (2 weeks)	2 months: one-stage, full-mouth disinfection group: significantly fewer pathogens and eradication of *Porphyromonas gingivalis*. 8 months: one-stage, full-mouth disinfection group: significant additional improvements (lower proportion of pathogens, fewer anaerobic species, larger reduction in spirochetes and motile organisms), especially during the first 2 months.
Bollen et al. (10)	One-stage, full-mouth disinfection (2 days) vs. scaling and root planing per quadrant (2 weeks)	4 months: one-stage, full-mouth disinfection resulted in a significant additional reduction/elimination of periodontopathogens, especially in the subgingival area, but also in the other intra-oral niches.
Mongardini et al. (43) Quirynen et al. (53) De Soete et al. (19)	One-stage, full-mouth disinfection (2 days) vs. scaling and root planing per quadrant (2 weeks)	8 months: (dark-field microscopy and culture data): one-stage, full-mouth disinfection resulted in significant additional improvements (larger reductions in the proportions of spirochetes and motile organisms in the subgingival flora, larger reductions in the number of colony-forming units/ml of anaerobic species, in the number of colony-forming units/ml of black-pigmented bacteria, and more significant reductions in the density of key pathogens, with even the eradication of *P. gingivalis*). The beneficial effects in the other niches were primarily restricted to the number of colony-forming units/ml of black-pigmented bacteria, especially on the mucosa and in the saliva and to a lesser extent on the tongue. 8 months: (checkerboard data): one-stage, full-mouth disinfection resulted in a significant additional reduction/elimination of periodontopathogens in pocket samples.
Apatzidou et al. (5)	Full-mouth scaling and root planing (1 day) vs. scaling and root planing per quadrant (2 weeks)	Both therapies showed significant improvements. Full-mouth scaling and root planing resulted in significantly greater reduction in the prevalence of *Treponema denticola* (months 3 and 6) and for *Prevotella intermedia* (month 3).
Koshy et al. (32)*	Full-mouth ultrasonic debridement (1 hour) vs. scaling and root planing per quadrant (1 week)	6 months: no significant differences in detection frequencies of target periodontopathogens between groups (polymerase chain reaction technique).
Jervoe-Storm et al. (29)	Full-mouth scaling and root planing (2 days) vs. scaling and root planing per quadrant (1 week)	6 months: no differences between groups, either in total bacterial counts or for selected target bacteria (polymerase chain reaction technique).
Zanatta et al. (82)*	Full-mouth ultrasonic debridement (1 hour) vs. scaling and root planing per quadrant (1 week)	Both therapies resulted in a temporary reduction in benzoyl-DL-arginine-naphthylamide (BANA) values (recurrence at month 3), without intergroup differences (BANA assay).

Treatment strategy: one-stage, full-mouth disinfection, full-mouth scaling and root planing/full-mouth ultrasonic debridement; scaling and root planing per quadrant.
*Only two of the five arms of the study are included.
Outcome variables: clinical attachment level, relative attachment level, bleeding upon probing, statistically significant, not statistically significant.

both immediately after insertion (0/20 vs. 7/22, respectively) as well as at membrane removal after 6 weeks (12/20 vs. 22/22, respectively), with an average of 1.5×10^7 viable organisms on the internal part of the membranes from the periodontally diseased group). The healthy group showed, concurrently, significantly more clinical gain in attachment (3.4 mm vs. 1.4 mm, respectively). The authors considered the following as sources of the pathogens: translocation from the remaining deep

pockets, the study defect site itself, or the epithelial surfaces from within and around the oral cavity. However, because bacteria from the last two sources were present in both study groups, one might conclude that the membrane-colonizing pathogens were probably transferred via saliva from infected and untreated periodontal lesions or from the other niches to the regenerative-treated periodontal site(s). Mombelli et al. (42) compared the clinical and microbial changes in the two deepest pockets, when tetracycline fibers (local application of antibiotics) were only applied to those deepest pockets (without further treatment to the remaining pockets), with those changes obtained when all teeth were cleaned and all pockets with a depth of >3 mm received a tetracycline fiber. After 6 months, significant 'additional' improvements (clinical as well as microbiological) were recorded in the test sites in the group of patients with fibers in all deep pockets. The deep pockets from patients where fibers were placed in all deeper pockets showed a probing depth reduction (1.7 mm) and attachment gain (0.7 mm) that was significantly higher than in the patients treated with restricted fiber placement (0.9 and 0.3 mm, respectively).

Full-mouth debridement without proper disinfection

Since 2005, five other centers (5, 29, 32, 79, 82) have examined the impact of a 'full-mouth approach' on the outcome of nonsurgical periodontal therapy (Table 3). These studies differ significantly from the Leuven trials in that they did not include proper disinfection of the intra-oral niches (besides the periodontal pockets), did not use a strong antiseptic during the initial healing time, and / or reduced the probability of intra-oral translocation of bacteria by giving instruction on optimal oral hygiene prior to therapy. The studies basically compared a quadrant-type therapy (often with intervals between each quadrant of only 1 week) with a full-mouth debridement approach (hand instrumentation or ultrasonic). Even though the outcome of the full-mouth approach was often superior, it was not always statistically significant.

Several factors can explain the difference between these five studies and the data from the Leuven group. First, part of the success of the one-stage, full-mouth disinfection protocol might be explained by the extensive use of chlorhexidine, even though several papers have indicated that the subgingival irrigation of pockets with an antiseptic does not have a major impact (for review see (51)). Koshy et al. (32) indeed showed the most benefit with a full-mouth approach. Accordingly, this study used antiseptics more intensively than the other studies (Table 3) because it used povidone-iodine irrigation subgingivally and a 0.05% chlorhexidine mouthrinse for 1 month. However, this approach was still less intensive compared with the procedure in the Leuven studies. The adjunctive benefits of locally applied antiseptics in conjunction with subgingival debridement are indeed limited in general. We recently conducted a study (57) in which a full-mouth approach was applied (similarly to our previous papers), but this time without the use of chlorhexidine, and the outcome clearly showed less benefit. The observation from this more recent study underlines again the significance of the use of chlorhexidine in the disinfection protocol. Second, in four out of the five studies from the other centers, the debridement was completed within a day; therefore, the Schwartzman reaction, suggested above, could not take place. Third, in four out of the five studies, extensive oral hygiene instruction had been given prior to debridement and therefore the probability of bacterial translocation was reduced. It is important to note that in the Leuven studies, optimal oral hygiene was only performed in the treated quadrants, in other words, a significant amount of plaque in at least one quadrant remained for up to 6 weeks after debridement of the first quadrant, thus allowing enough time for bacterial translocation. Finally, the best results with the one-stage, full-mouth disinfection protocol were recorded in deep pockets, but most of the above-mentioned studies from other centers enrolled patients with only moderate periodontitis. Indeed, in our most recent study (57) of patients with a similar degree of periodontitis, the beneficial effect of the one-stage full-mouth disinfection was less impressive.

The microbiological analyses included in some of the studies mentioned above (Table 2) (5, 29, 32, 82) revealed only minor additional improvements with the full-mouth approach, which again is not in accordance with the Leuven papers and seems to point to the importance of the above-mentioned factors specific for the one-stage, full-mouth concept (i.e. antiseptics, Schwartzman reaction, timing and oral hygiene) and the type of microbial analysis (culture vs. polymerase chain reaction; quantitative analysis vs. detection frequency).

None of the studies performed at other centers reported any negative outcomes of a full-mouth strategy, and most studies indicated a significant reduction in treatment time, especially after full-mouth ultrasonic debridement.

Table 3. Summary of clinical data obtained with different protocols in different centres involving a full-mouth concept (but not a one-stage, full-mouth disinfection protocol)

Authors	Treatment Strategy	Antiseptics used in the full-mouth group			Status prior to therapy	n	Outcome: comparison between strategies
		Chair side		Home			
		Subgingivally	Oral niches				
Apatzidou et al. (5)	Full-mouth scaling and root planing (1 day) vs. scaling and root planing per quadrant (2 weeks)	None	None	None	No oral hygiene instruction prior to therapy	20/20	6 months: probing pocket depth improvements were similar; relative attachment level changes were statistically significantly greater in the full-mouth group for pockets ≥ 7 mm (2.2 ± 0.8 mm vs. 1.4 ± 0.8 mm); the bleeding upon probing reduction was similar.
Wennström et al. (79)	Full-mouth ultrasonic debridement/full-mouth (1 hour) vs. scaling and root planing per quadrant (1 week)	None	None	None	Oral hygiene instruction 3 weeks before therapy	20/21	6 months: probing pocket depth improvements were similar; Δ relative attachment level changes were similar; bleeding upon probing reduction was similar; treatment time was statistically significantly shorter in the full-mouth group.
Koshy et al. (32)*	Full-mouth ultrasonic debridement (1 hour) vs. scaling and root planing per quadrant (1 week)	1% povidine iodine irrigation	None	Chlorhexidine 0.05%: 1 month	Oral hygiene instruction before therapy	12/12	6 months: probing pocket depth improvements were similar; clinical attachment level changes were similar; per cent of sites ≥ 5 mm probing pocket depths were statistically significantly more reduced in the full-mouth group; bleeding upon probing reduction was statistically significantly greater in the full-mouth group; treatment time was statistically significantly shorter in the full-mouth group.
Jervoe-Storm et al. (29)	Full-mouth scaling and root planing (2 days) vs. scaling and root planing per quadrant (1 week)	None	None	None	Oral hygiene instruction until optimal plaque control prior to therapy	10/10	6 months: probing pocket depth improvements were similar; relative attachment level changes were similar; bleeding upon probing reduction was similar; treatment time was statistically significantly shorter in the full-mouth group.
Zanatta et al. (82)*	Full-mouth ultrasonic debridement (1 hour) vs. scaling and root planing per quadrant (1 week)	0.5% povidine iodine irrigation	None	None	Oral hygiene instruction prior to therapy; supragingival plaque retention factors (including calculus) removed prior to therapy	15/15	3 months: probing pocket depth improvement was similar; clinical attachment level changes were similar; bleeding upon probing reduction was similar; treatment time was statistically significantly shorter in the full-mouth group.
Quirynen et al. (57)*	Full-mouth scaling and root planing (2 days) vs. scaling and root planing per quadrant (2 weeks)	None	None	None	No oral hygiene instruction prior to therapy	15/14	8 months: probing pocket depth improvement showed slightly more reduction in the full-mouth scaling and root planing group (P = 0.1); clinical attachment level showed slightly more gain in the full-mouth scaling and root planing group (P = 0.06).

Treatment strategy: full-mouth scaling and root planing/full-mouth ultrasonic debridement; scaling and root planing per quadrant.

*Only two of the three arms of the study are included here.

Outcome variables: clinical attachment level, relative attachment level, bleeding upon probing, probing pocket depth, statistically significant.

Reflections on previous review papers

Several review papers (6, 20, 24, 31) have been published on the one-stage, full-mouth disinfection strategy. In these review papers, the data of the Leuven studies were often incorrectly quoted or interpreted, for the following reasons. A recurrent remark is the fact that in our studies the baseline probing depths and attachment levels were measured immediately after scaling and root planing. This was unavoidable because the patients enrolled in the studies showed significant amounts of supragingival and subgingival calculus, a factor that makes consistency of pocket probing prior to scaling unreliable (11). However, because this method had been applied in both test and control groups, it cannot contribute to differences between both treatment strategies. It only makes comparisons with other clinical trials less obvious. The clinical results in the control group have been considered to be below what one can expect from a thorough mechanical debridement. One should take into consideration that these patients did not receive any additional periodontal therapy over the entire 8-month period. Owing to the lack of oral hygienists in Belgium, the overall degree of plaque control obtained was sometimes not optimal because it would have implied too-frequent recall sessions at the University Hospital. Moreover, the longer the interval up to the completion of the last quadrant (6 weeks), the higher the probability of bacterial translocation, especially in view of the fact that patient compliance with optimal oral hygiene declined with time. Nevertheless, the data reported in the large-scale study (43) appears to be comparable with the general observations from the reviews of the literature by Cobb (12, 13). Specifically, when comparing results using full-mouth disinfection vs. standard treatments, single-rooted and multirooted teeth with periodontal pockets of ≥7 mm (mean 7.5 mm) showed a reduction of 1.9 and 1.6 mm, respectively, for adult patients with chronic periodontitis, and 2.2 and 1.9 mm for patients with early onset periodontitis (mean initial pocket depth 8.0 mm), respectively. These observations are in line with the 2.2 mm reported by Cobb, especially when the range of data within his review is considered (1.7–2.2 mm for pockets ≥ 7 mm). Even more convincing is the significance of the microbial improvements with the one-stage, full-mouth disinfection approach when compared with the standard therapy. This observation is generally overlooked in these reviews,

although this superiority was clearly illustrated in several papers (19, 53). The microbiologists involved, using culture techniques or DNA–DNA hybridization, were always blinded to the therapy. Thus, these observations deserve greater attention. The only study attempting to perform a one-stage full-mouth disinfection, however, with a weaker antiseptic, also included a microbiological analysis (32). The absence of clear microbial differences is unfortunately often misinterpreted because these authors used qualitative polymerase chain reaction to detect the presence or absence of selected periodontopathogens (detection frequencies). Although these results are interesting, they are not comparable with the quantitative microbial culture data from the Leuven studies. The role of chlorhexidine in the full-mouth disinfection protocol has been questioned. Therefore, we analyzed the role of chlorhexidine in this full-mouth disinfection approach in a pilot study (54). In this trial, a third group (one-stage, full-mouth scaling and root planing without further disinfection with an antiseptic) was added to an ongoing study. The design of this pilot study is not optimal, and bias of the examiners cannot be excluded. Therefore, as mentioned in the paper itself (57), a new large-scale study was conducted in order to verify these findings. The observations indicated that the benefits of the one-stage, full-mouth disinfection protocol are partially a result of the use of the antiseptics and partially because of the completion of the therapy in a short time. Another frequent comment in these reviews is that by using a staged approach, it is possible to monitor and correct the patient's oral hygiene better during the four visits. However, a one-stage full-mouth approach does not restrict the clinician to include extra sessions to monitor the patient's oral hygiene. Moreover, as discussed below, because optimal plaque control is still the cornerstone of successful treatment of periodontitis and/or in maintaining periodontal health, it may be advisable to start with oral hygiene instruction in order to verify the motivation and co-operation of the patient. Finally, it is surprising that the latest review papers suggest or state that no further research is needed on the one-stage, full-mouth disinfection approach (20, 35). This is in clear contradiction with the existing controversies and unresolved issues. Furthermore, other than the Leuven studies, no other study has ever been published in which a genuine one-stage, full-mouth disinfection approach was used, with the exception of the Koshy study, where a less potent disinfection protocol was used (32) (Table 3). The suggestion of not performing more research on the

one-stage full-mouth disinfection approach is primarily based on the so-called clinically insignificant benefits. It needs to be pointed out that the Koshy study showed that a one-stage full-mouth approach resulted in 26% more sites with a reduction in pocket depths to <5 mm when compared with a staged approach. Additionally, the latest systematic reviews (20, 35) reported that changes in pocket depths and clinical attachment levels are similar to what can be achieved by the adjunctive use of systemic antibiotics (25). With the ever-increasing development of antibiotic resistance among bacteria, including oral bacteria (72, 73), researchers should be encouraged to explore alternative, nonantibiotic treatment approaches.

Two recent papers have employed a true 'systematic' analysis. Eberhard et al. (20) compared results for all randomized clinical trials using a scaling approach, with or without the use of antiseptics, and a quadrant scaling approach (control). Of 216 identified abstracts, only seven trials could be included in their systematic analysis, based on their selection criteria. The number of papers was too small to draw final conclusions, but the full-mouth approach with antiseptics often showed significant additional improvements. Lang et al. (35) assessed the clinical and microbiological effects of a full-mouth protocol with or without disinfection, in comparison with conventional staged debridement in patients with chronic periodontitis after at least 6 months. Their search of MEDLINE covered a period from 1975 to October 2007 and yielded 207 titles. Forty-two abstracts and 17 full-text articles were screened for inclusion. Twelve articles allowed a direct comparison to be made of full-mouth disinfection with conventional staged debridement, full-mouth scaling and root planing with conventional staged debridement, and full-mouth disinfection with full-mouth scaling and root planing. No distinction was made between protocols with little to no use of antiseptics or with extensive use of antiseptics. Nevertheless, pocket probing depth reductions and gain in clinical attachment were significantly greater with a full-mouth disinfection approach. Single-rooted teeth and deep pockets benefited most from a full-mouth disinfection approach.

Candidates for a one-stage, full-mouth disinfection approach

Because the main goal of the one-stage, full-mouth disinfection approach is the prevention of intra-oral cross-contamination, this approach may offer the largest benefits in specific clinical conditions, as follows.

Severe periodontitis

As the number of periodontopathogens in saliva increase significantly with increasing severity of periodontitis (15, 71), the likelihood of cross-contamination will be higher in patients with periodontitis. Indeed, two recent studies clearly illustrated that the microbial load in the saliva is significantly reduced in periodontitis patients after therapy. This reduction was responsible for a reduced rate of de novo supragingival plaque formation (15, 60). Thus, in patients with severe periodontitis, a one-stage, full-mouth approach will result in an immediate reduction of the microbial load and in delayed de novo plaque formation (63), which might result in a delayed subgingival recolonization.

Patients with high amounts of plaque and calculus accumulation

As the supragingival plaque contains both viable aerobic and anaerobic bacteria (70), patients with high levels of supragingival plaque and calculus are candidates for cross-contamination. They may benefit most from a one-stage, full-mouth approach. Supragingival plaque control indeed is of major importance in lowering the risk of bacterial translocation (66, 67).

Risks factors and patients acceptance

It is, of course, correct to state that 'before new treatment methods can be introduced into daily 'dental' practice, it is indispensable to compare the new therapeutic approaches with existing and proven treatment methods' (6). In a one-stage, full-mouth disinfection protocol there are no risks, either for the patient's health or for bacterial resistance. These aspects should be considered, especially when systemic antibiotics are envisaged by some. Eventually, some patients can become allergic to chlorhexidine, but the incidence of this is extremely low (around 50 anaphylaxis cases worldwide over the past 10 years (7). In patients at risk after a bacteremia, the proper standard prophylactic measures should, of course, be considered, but with the one-stage

concept, antibiotic coverage can be restricted to, for example, a single period of 2 days.

Economic aspect

There are several potential economic advantages for the patient as well as for the clinician. Most patients indeed seem to prefer a one-stage, full-mouth strategy (43) because it is easier to organize (two instead of four appointments), involves less travelling and because it is easier for the patient to understand (to date, most other infectious diseases are treated via a global approach). The clinician can work for 2 h with the same patient, limiting intervals between patients. The chair time thus becomes more efficient and replacement of instruments and other materials is less frequent. In our clinic at Leuven a better compliance with the appointments is observed when a one-stage full-mouth strategy is used.

Modifications of the one-stage, full-mouth disinfection protocol

Optimal plaque control is still the cornerstone of a successful treatment of periodontitis and ∕ or in maintaining periodontal health. Supragingival plaque control affects both the total number of bacteria and the composition of the subgingival microbiota. This may be the result of a direct effect of the supragingival colonizers on subgingival organisms and ∕ or an effect on the adjacent periodontal tissues (healing of periodontium has an indirect effect on subgingival flora). Indeed, removal of the supragingival plaque and the resulting improvements in the clinical health of the marginal gingiva may reduce essential growth requirements for the subgingival flora so that bacterial numbers will decrease spontaneously (66). This beneficial aspect has been illustrated in several clinical trials examining the impact of repeated supragingival professional cleaning on the subgingival flora (3, 16, 28). The compliance of a patient with oral hygiene is often difficult to predict. Therefore, it may be advisable to start with oral hygiene instruction in order to verify the collaboration of the patient. During these sessions the subgingival plaque can also be reduced by means of sonic or ultrasonic devices. This approach can, however, sometimes result in a periodontal abscess as a consequence of healing of the gingival margin and closure of the pocket entrance, encapsulating remaining subgingival calculus.

Conclusions

The one-stage, full-mouth disinfection concept results in significant additional clinical and microbiological improvements with nonsurgical periodontal therapy. The new concept has no disadvantages and ∕ or risks for the patient. The clinician and the patient therefore can only gain via a better outcome of the mechanical debridement, reduced need for surgery, and more efficient treatment and time management, with less travelling or absence from work for the patient. A scientific explanation for the success of this concept has not yet been obtained. Reduction in the probability of bacterial cross-contamination, optimal combination ∕ application of antiseptics and ∕ or the Schwartzman reaction may be contributing factors. More research is needed to explore in greater detail the potential of the one-stage, full-mouth disinfection, and to improve its applicability and benefits.

Acknowledgments

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