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A systematic review of the effects of full-mouth debridement with and without antiseptics in patients with chronic periodontitis

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Abstract

Objectives: To assess the clinical and microbiological effects of full-mouth debridement with (FMD) and without the use of antiseptics [full-mouth scaling and root planing (FMSRP)] in comparison with conventional staged debridement (CSD) in patients with chronic periodontitis after at least 6 months.

Material and Methods: The search in MEDLINE (PubMed), covering a period of 1975 to October 2007, and hand searching yielded 207 titles. Forty-two abstracts and 17 full-text articles were screened for inclusion.

Results: Twelve articles allowed a direct comparison of FMD with CSD, FMSRP with CSD and FMD with FMSRP. Probing pocket depth reductions were significantly greater (0.2 mm) with FMD and FMSRP compared with CSD. Moreover, a modest reduction in BOP (9%) favoured FMD. Likewise, clinical attachment levels were improved by 0.2–0.4 mm in favour of FMD and FMSRP, respectively. In all comparisons, single-rooted teeth and deep pockets benefitted slightly from FMD and FMSRP. Limited differences in the changes of the subgingival microbiota were noted between the treatment modalities.

Conclusions: Despite the significant differences of modest magnitude, FMD or FMSRP do not provide clinically relevant advantages over CSD. Hence, all three treatment modalities may be recommended for debridement in the initial treatment of patients with chronic periodontitis.

Key words: chronic periodontitis; clinical trials; debridement; full-mouth disinfection; initial therapy; RCT; root planing; scaling

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Realizing that in fully dentate or partially edentulous patients, the untreated periodontal pockets may represent a significant reservoir for the reinfection of adjacent sites following active periodontal therapy (Mombelli et al. 1996), a concept of full-mouth debridement (FMD) within 1 day has been developed. Although single periodontal sites were successfully treated, reinfection with pathogens occurred within 2 months in these sites, while an attempt to fully disinfect the oral cavity using local tetracycline fibres in all sites with probing depths >3 mm and supplemental use of antiseptics to deplete the supragingival bacterial load resulted in a stable healing of the treated sites and maintenance of therapeutic effects with absence of pathogens over time (Mombelli et al. 1996, 1997, Fourmousis et al. 1998).

In order to avoid intra-oral transmission of periodontal pathogens from periodontal pockets to recently instrumented and healing periodontal sites, a FMD concept was propagated by the Leuven group (Quirynen et al. 1995). The original FMD concept included the disinfection of the entire oral cavity within a period of 24 h, depletion of the supragingival plaque deposits and prevention of biofilm formation by means of oral rinses with chlorhexidine twice daily for 1 min. for 2 weeks and

Conflict of interest and source of funding statement

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disinfection of bacterial reservoirs of the tongue and tonsils by tongue scraping and spraying the tonsillar region with chlorhexidine. Furthermore, subgingival irrigation of all the pockets three times within 10 min. with a 1% chlorhexidine gel was performed and repeated after 8 days. It was hypothesized that periodontal treatment consisting of quadrant- or sextant-wise instrumentation at usually 1–2-week intervals would lead to reinfection of the instrumented sites before the completion of the entire therapy. Hence, an FMD should help prevent such reinfection of already treated pockets from sites that were not yet instrumented.

While some clinicians immediately adopted this novel concept, other clinical researchers questioned the validity and/or the superiority of FMD over the quadrant-wise scaling and root planing termed ''conventional staged debridement'' (CSD). Moreover, several clinicians modified the original concept by omitting the disinfection of the oral cavity with chlorhexidine or they applied less efficacious antiseptic rinses than chlorhexidine. Hence, full-mouth scaling and root planing (FMSRP) without the use of antiseptics was also advocated.

In recent years, a number of studies have been presented with the aim of elucidating various clinical and microbiological effects of FMD or FMSRP in comparison with CSD. The present systematic review aimed at the evaluation of randomized-controlled clinical trials (RCT) focusing on both the clinical and the microbiological effects.

The following focused question was raised:

''In patients with chronic periodontitis, what are the clinical and microbiological outcomes of Full Mouth Debridement (FMD) *versus* Conventional Staged Debridement (CSD) after a follow-up period of at least six months?''

Material and Methods

Search strategy and study selection

A MEDLINE (PubMed) search from 1975 up to and including October 2007 was conducted. The search terms used were ''full-mouth disinfection'', ''debridement'', ''scaling'', ''root planing'', ''initial therapy'', ''chronic periodontitis'', and ''clinical trial'' (Table 1).

Inclusion criteria

To be eligible for inclusion in this systematic review, studies had to be

Table 1. Characteristics of studies included

References	Study	Year of publication	Study design	No. of patients	Interventions	Age range	Mean age	Location	Follow-up (months)	Variables
1	Vandekerckhove et al.	1996	RCT	10	FMD *versus* CSD	39–62	49.6	Leuven	8	GI, PII, BOP, PPD
6	Bollen et al.	1996	RCT	10	FMD *versus* CSD	39–62	49.6	Leuven	8	MicroBiol. (DPCM, culture)
7	Quirynen et al.	1999	RCT	24	FMD *versus* CSD	23–69	48.5	Leuven	8	MicroBiol. (DPCM, culture)
12	Quirynen et al.	2000	RCT	36	FMD *versus* FMSRP *versus* CSD	37–69	NR	Leuven	8	GI, PI, BOP, PD, CAL, MicroBiol.
8	De Soete et al.	2001	RCT	19	FMD *versus* CSD	41–69	NR	Leuven Boston	8	DNA hybridization
3	Apatzidou & Kinane	2004a	RCT	40	FMSRP *versus* CSD	31–70	45	Glasgow	6	BOP, PPD, CAL
9	Apatzidou & Kinane	2004b	RCT	40	FMSRP *versus* CSD	31–70	45	Glasgow	6	PCR
16	Koshy et al.	2005	RCT	36	FMD *versus* FMSRP *versus* CSD	34–66	50.4	Tokyo	6	PII, BOP. PPD, CAL
13	Wennström et al.	2005	RCT	42	FMSRP *versus* CSD	27–70	49.8	Göteborg	6	PII, BOP, PPD, CAL, % of closed pockets i.e. PD $\leqslant$ 4 mm
4	Quirynen et al	2006	RCT	71	FMD *versus* FMSRP *versus* CSD (various rinses)	30–75	48.0	Leuven	8	PII, SBI, BOP, PPD, REC, staining
17	Jervøe-Storm et al.	2006	RCT	20	FMSRP *versus* CSD	NR	53.1	Bonn	6	PII, BOP, PPD, CAL
10	Jervøe-Storm et al.	2007	RCT	20	FMSRP *versus* CSD	NR	53.1	Bonn	6	Real-time PCR

RCT, randomized-controlled clinical trial; FMD, full-mouth disinfection with use of antiseptics; FMSRP, full-mouth scaling and root planing; CSD, conventional staged debridement; GI, gingival index; PII, plaque index; BOP, bleeding on probing; PPD, pocket probing depth; CAL, clinical attachment level; REC, recession.

RCTs of at least 6 month's duration. Studies were considered for inclusion if they included patients with chronic periodontitis only. However, for a direct comparison of FMD with FMSRP and CSD, one study that had added the FMSRP cohort to a running RCT and, hence, did not strictly qualify as an RCT with three modalities was considered anyway (Quirynen et al. 2000). This decision was based on the fact that the clinical investigators were the same for the three treatment groups and were blinded, thus justifying comparison between the three treatment groups, although the issue of selection bias was not addressed.

Studies involving patients with specifically aggressive periodontitis were not considered.

Outcome variables

The primary outcome variables assessed were differences at the end of the studies in probing pocket depth (PPD), incidence of bleeding on probing (BOP) and clinical attachment level (CAL). Differences at baseline where not taken into account. Other outcome variables examined were microbiological changes attributed to treatment.

Selection of studies

Titles and abstracts of the search results for possible inclusion were initially screened by two groups of independent reviewers (N. P. L. and T. W. C.; M. A. K.). The full texts of all studies of possible relevance were obtained for independent assessment by the reviewers. Any disagreement was resolved by discussion.

Data were extracted independently by the reviewers using a data extraction form. Disagreement regarding data extraction was resolved by consensus. Agreement concerning study inclusion and quality assessment was determined by κ-statistics.

Statistical analysis

Studies were combined in meta-analyses to evaluate the treatment effects of FMD, FMSRP and CSD, respectively. The meta-analyses were performed using the statistical software package STATA Version 10 (Stata Corporation, College Station, TX, USA). Results were presented as weighted mean differences [WMD with 95% confidence interval (CI)]. A fixed-effects model was used and the extent of statistical heterogeneity was calculated. Variance imputation methods were used to estimate appropriate variance estimates in some studies, where appropriate standard deviations of the differences were not included in study reports (Follmann et al. 1992).

For the PPD and CAL, separate analyses were performed for single- and multi-rooted teeth as well as for moderate (5–6 mm) and deep ($\geqslant$7 mm) pockets.

Results

From a yield of 205 titles, 42 papers were selected and abstracts were obtained. κ-statistic for the first screening was $K = 0.705$. Following screening, both reviewers agreed on 15 titles for further evaluation. κ-statistic for the second screening on the abstract level was $K = 0.483$. This lower K value was due to substantial diversity in papers reporting on FMD with antiseptic applications other than the use of chlorhexidine. Agreement on the included full-text papers was reached by discussion and consensus was obtained that chlorhexidine was to be evaluated as the antiseptic accompanying FMD, whenever possible. Hand searching resulted in the addition of two papers.

Subsequently, 17 articles meeting the inclusion criteria were evaluated by both reviewers (Fig. 1). All studies included were evaluated for compliance with the CONSORT guidelines (http://www.consort-statement.org).

Excluded studies

Of the 17 full-text articles examined, five had to be excluded from the final analysis (see reference list: # 2, 5, 11, 14, 15). The reasons for exclusion were an inadequate mean follow-up time ($<$6 months), the study not reporting on outcome variables, the study not reporting on FMD with antiseptics or multiple publications on the same patients.

Data extraction

Finally, 12 studies were included (Fig. 1). Information on changes in probing depth, incidence of BOP and changes in CALs, as well as microbiological changes and adverse reactions to treatment at the 6- or 8-month observations was retrieved. Five studies reported on clinical outcomes, two studies examined both clinical and microbiological outcomes, while five studies reported on microbiological changes alone. Four studies examined FMD with supplemental

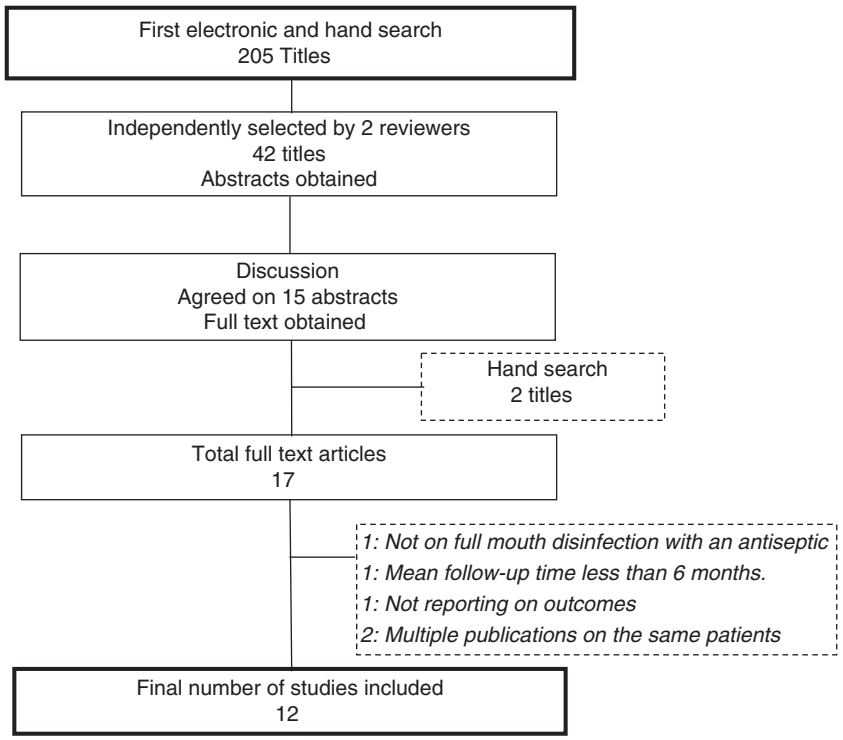

Fig. 1. Search strategy.

application of antiseptic rinses (e.g. chlorhexidine) *versus* CSD six studies examined FMSRP *versus* CSD, and three studies compared all the three treatment modalities.

Differences in PPD at the end of the studies

FMD (with the use of antiseptics) versus *CSD*

Based on four studies (# 1, 4, 12, 16) totalling 87 patients, the weighted mean difference (95% CI) between FMD and CSD amounted to − 0.27 mm (− 0.43, − 0.12) favouring FMD ($p < 0.0001$) (Fig. 2).

For single-rooted teeth, the weighted mean difference (95% CI) between FMD and CSD amounted to − 0.33 mm (− 0.52, − 0.13) ($p = 0.001$) and − 0.19 mm (− 0.44, 0.06) (NS) for multi-rooted teeth, respectively (Fig. 3).

For moderate pockets (5 − 6 mm), the weighted mean difference (95% CI) between FMD and CSD amounted to − 0.20 mm (− 0.38, − 0.02) ($p = 0.025$) and − 0.50 mm (− 0.81, − 0.19) ($p = 0.001$) for deep pockets to (⩾7 mm), respectively (Fig. 4).

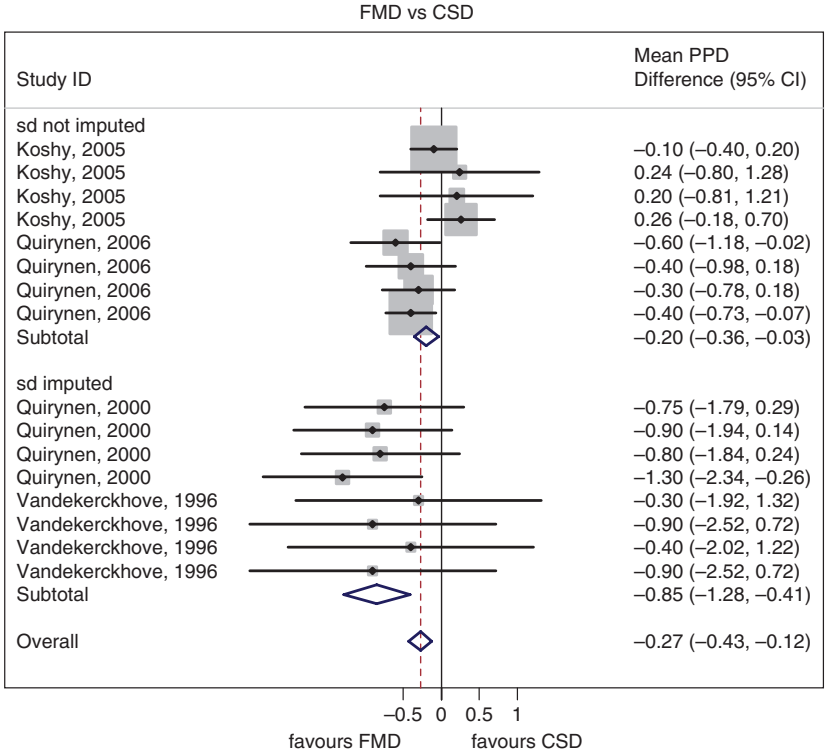

Fig. 2. Weighted mean Difference (95% CI) of PPD between FMD and CSD. *p*-value for heterogeneity: 0.206I^2: 27.9% (SD not imputed studies); 0.982I^2 0% (SD imputed studies).

FMSRP (without the use of antiseptics) versus *CSD*

Based on six studies (# 3, 4, 12, 13, 16, 17) totalling 178 patients, the weighted mean difference (95% CI) between FMSRP and CSD amounted to − 0.13 mm (− 0.23, − 0.03) favouring FMSRP ($p = 0.008$) (Fig. 5).

Three studies (# 3, 13, 17) did not provide the data for the sub-analysis on single- *versus* multi-rooted teeth and one study (# 3) lacked information to allow sub-analysis on various PPD.

For single-rooted teeth, the weighted mean difference (95% CI) between FMSRP and CSD amounted to − 0.34 mm (− 0.55, − 0.12) ($p = 0.002$) and to − 0.29 mm (− 0.51, 0.07) ($p = 0.009$),for multi-rooted teeth respectively (Fig. 6).

For moderate pockets (5–6 mm), the weighted mean difference (95% CI) between FMSRP and CSD amounted to − 0.13 mm (− 0.20, 0.02) (NS) and to − 0.43 mm (− 0.66, − 0.19) ($p < 0.0001$) for deep pockets (⩾7 mm), respectively (Fig. 7).

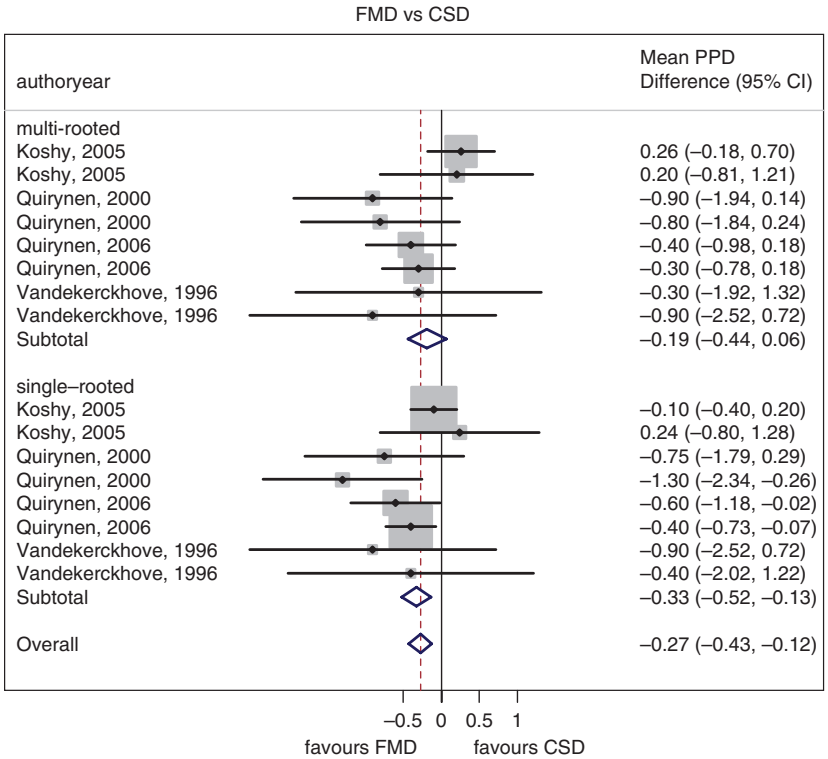

Fig. 3. Weighted mean Difference (95% CI) of PPD between FMD and CSD, stratified based on single- and multi- rooted teeth. *p*-value for heterogeneity: 0.245I^2: 23.2% (multi-rooted); 0.271I^2 20.1% (single-rooted).

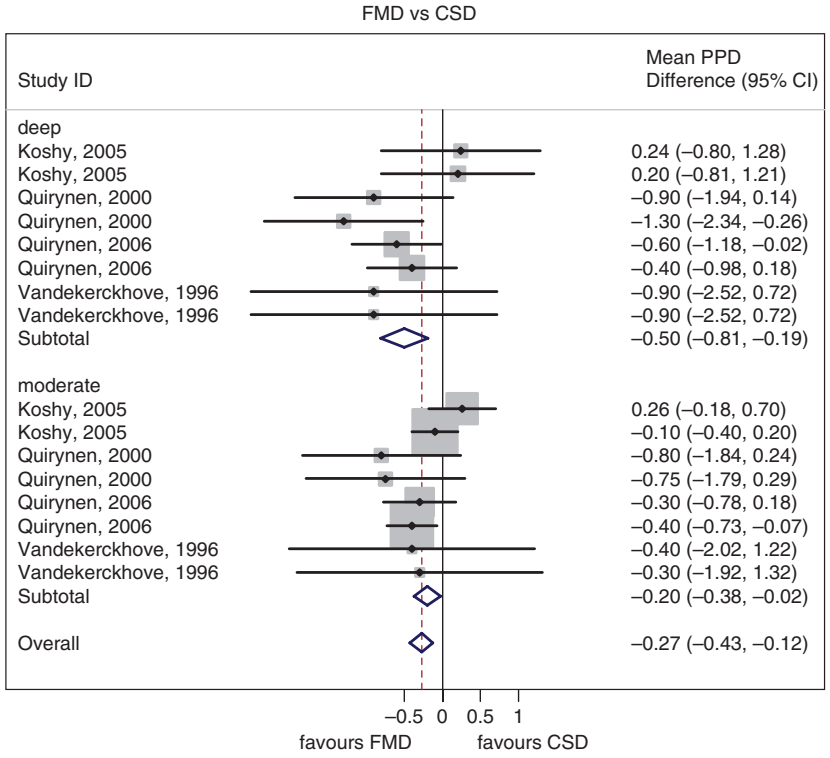

Fig. 4. Weighted mean Difference (95% CI) of PPD between FMD and CSD, stratified based on moderate (5–6 mm) and deep (⩾7 mm) pockets. *p*-value for heterogeneity: 0.398I^2: 4.2% (deep); 0.284I^2 18.4% (moderate).

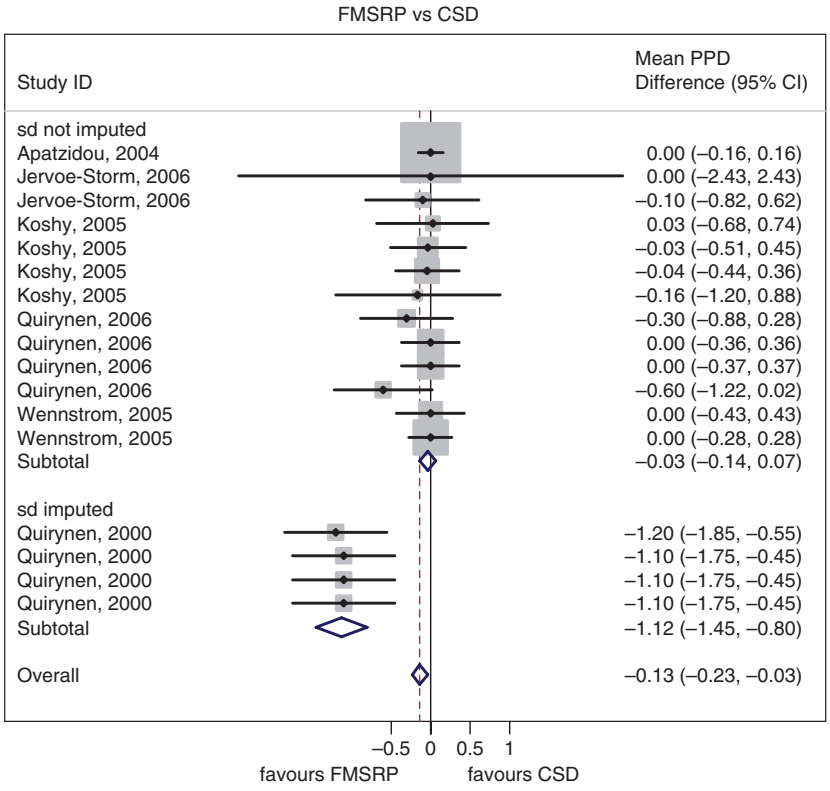

Fig. 5. Weighted mean Difference (95% CI) of PPD between FMSRP and CSD. *p*-value for heterogeneity: 0.974I^2: 0% (SD not imputed studies); 0.995I^2 0% (SD imputed studies).

FMD (with the use of antiseptics) versus *FMSRP (without the use of antiseptics)*

Based on five studies (# 3, 4, 13, 16, 17) totalling 209 patients, the weighted mean difference (95% CI) between FMD and FMSRP amounted to – 0.03 mm (– 0.14, 0.07) (NS) (Fig. 8).

Sub-analysis for single- or multi-rooted teeth and for various PPD yielded no significant weighted mean differences between FMD and FMSRP either.

Changes in incidence of BOP at the end of the studies

FMD (with the use of antiseptics) versus *CSD*

Based on the four studies (# 1, 4, 12, 16) mentioned (87 patients), the weighted mean difference (95% CI) between FMD and CSD amounted to a reduction in BOP of – 8.75% (– 15.83, – 1.67) favouring FMD ($p = 0.015$) (Fig. 9).

For single-rooted teeth, the weighted mean difference (95% CI) between FMD and CSD amounted to – 6.99% (– 18.05, 04.07) (NS) and to 0.09% (– 15.11, 14.93) (NS), for multi-rooted teeth – respectively.

For moderate pockets (5–6 mm), the weighted mean difference (95% CI) between FMD and CSD amounted to – 8.41% (– 21.10, 4.29) (NS) and to 0.84% (– 13.34, 11.66) (NS), for deep pockets (⩾7 mm) – respectively.

FMSRP (without the use of antiseptics) versus *CSD*

Based on six studies (# 3, 4, 12, 13, 16, 17) mentioned (178 patients), the weighted mean difference (95% CI) between FMSRP and CSD amounted to 8.45% (8.35, 8.54) favouring CSD ($p < 0.0001$) (Fig. 10).

Only one study (# 4) provided the data of a sub-analysis on single- *versus* multi-rooted teeth. In this study, the mean difference (95% CI) between FMSRP and CSD amounted to 12.31% (12.20, 12.43) ($p < 0.0001$) for single-rooted and to 0.25% (0.09, 0.42) ($p = 0.003$) for multi-rooted teeth, respectively.

For moderate pockets (5–6 mm) (two studies; # 4, 17), the weighted mean difference (95% CI) between FMSRP and CSD amounted to 10.19% (10.06, 10.31) ($p < 0.0001$) and to6.34% (6.19, 6.48) ($p < 0.0001$), for deep pockets (⩾7 mm) respectively.

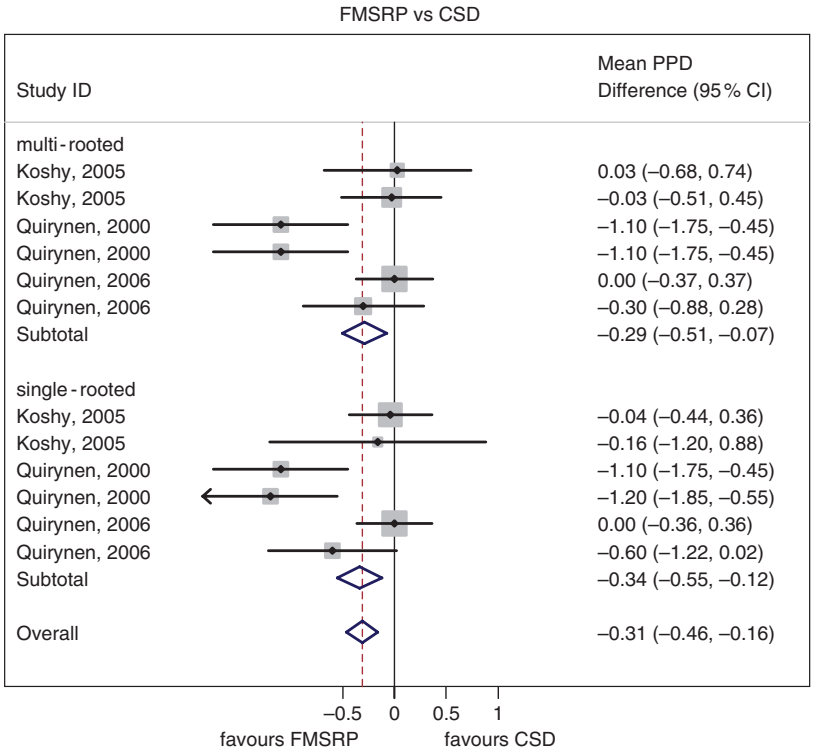

Fig. 6. Weighted mean Difference (95% CI) of PPD between FMSRP and CSD, stratified based on single- and multi-rooted teeth. *p*-value for heterogeneity: 0.006I^2: 69.2% (multi-rooted); 0.003I^2 72.7% (single-rooted).

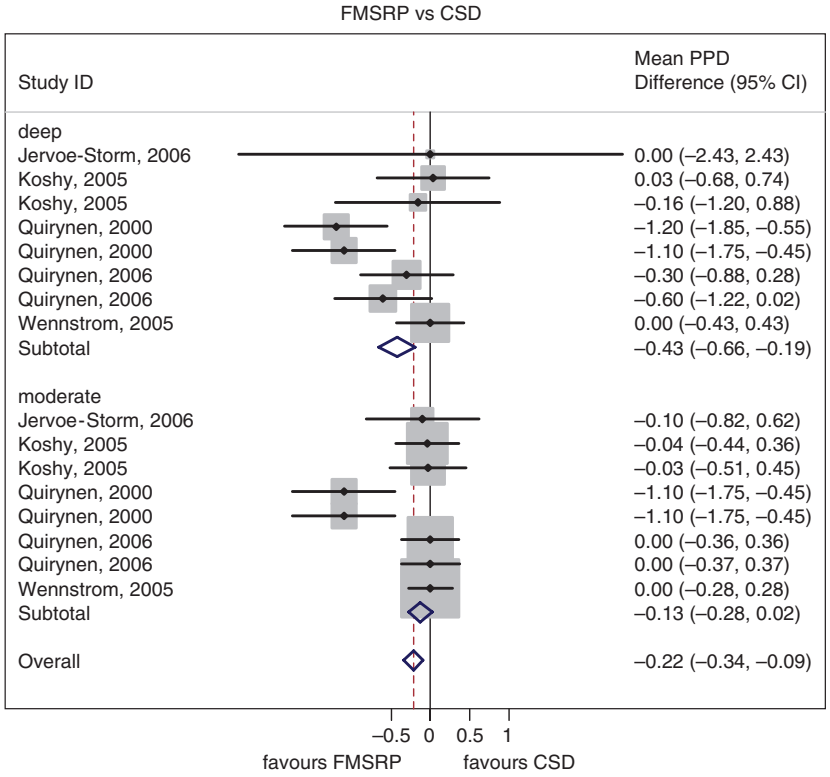

Fig. 7. Weighted mean Difference (95% CI) of PPD between FMSRP and CSD, stratified based on moderate (5–6 mm) and deep (⩾7 mm) pockets. *p*-value for heterogeneity: 0.027I^2: 55.8% (deep); 0.007I^2 63.8% (moderate).

FMD (with the use of antiseptics) versus *FMSRP (without the use of antiseptics)*

Based on three studies (# 4, 12, 16) mentioned (76 patients), the weighted mean difference (95% CI) between FMD and FMSRP amounted to – 5.72% (– 12.65, 1.21) (NS) (Fig. 11).

Only one study (# 4) provided the data of a sub-analysis for single- or multi-rooted teeth as well as for various PPD and yielded no significant differences between FMD and FMSRP either.

Changes in CAL at the end of the studies

FMD (with the use of antiseptics) versus *CSD*

Based on three studies indicated (# 4, 12, 16), the weighted mean difference (95% CI) between FMD and CSD amounted to 0.21 mm (0.02, 0.40) favouring FMD ($p = 0.032$) (Fig. 12).

For single-rooted teeth, the weighted mean difference (95% CI) between FMD and CSD amounted to 0.41 mm (0.04, 0.77) ($p = 0.029$) and to 0.06 mm (– 0.18, 0.31) (NS) for multi-rooted teeth, respectively (Fig. 13).

For moderate pockets (5–6 mm), the weighted mean difference (95% CI) between FMD and CSD amounted to 0.10 mm (– 0.12, 0.32) (NS) and to 0.56 mm (0.16, 0.95) ($p = 0.006$) for deep pockets (⩾7 mm), respectively (Fig. 14).

FMSRP (without the use of antiseptics) versus *CSD*

Based on the six studies indicated (# 3, 4, 12, 13, 16, 17), the weighted mean difference (95% CI) between FMSRP and CSD amounted to 0.36 mm (0.23, 0.49) favouring FMSRP ($p < 0.0001$) (Fig. 15).

Two studies (#12, 16) provided the data for sub-analysis on single- *versus* multi-rooted teeth and five studies (# 4, 12, 13, 16, 17) provided information to allow sub-analysis on various PPD.

For single-rooted teeth, the weighted mean difference (95% CI) between FMSRP and CSD amounted to 0.88 mm (0.57, 1.19) ($p < 0.0001$) and to 0.69 mm (0.42, 0.96) ($p < 0.0001$) for multi-rooted teeth, respectively (Fig. 16).

For moderate pockets (5–6 mm), the weighted mean difference (95% CI) between FMSRP and CSD amounted to 0.30 mm (0.12, 0.48) ($p = 0.001$)

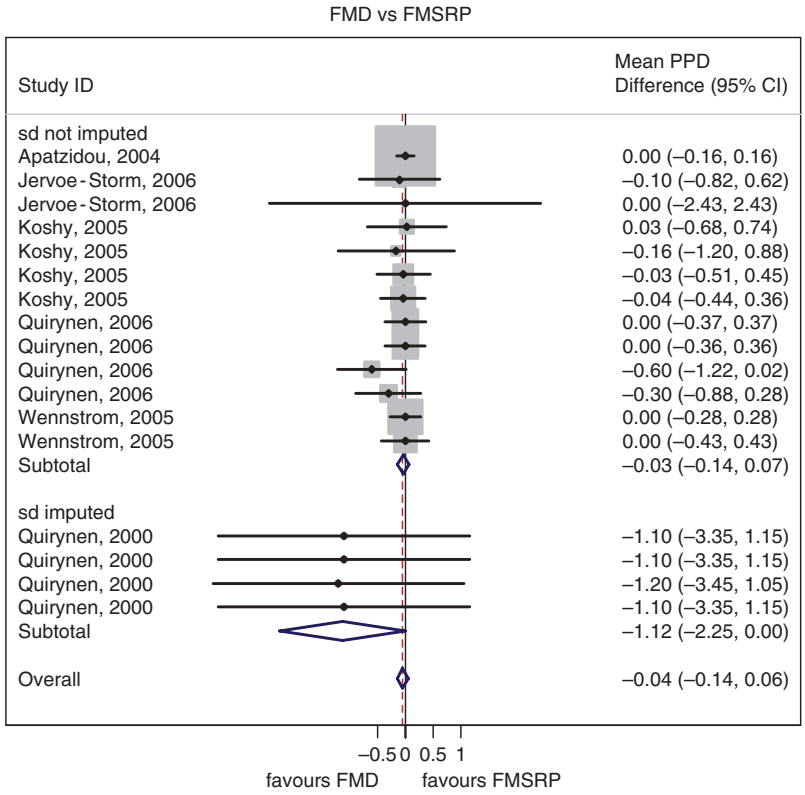

Fig. 8. Weighted mean Difference (95% CI) of PPD between FMD and FMSRP. *p*-value for heterogeneity: 0.974I^2: 0% (SD not imputed studies); 1.0I^2 0% (SD imputed studies).

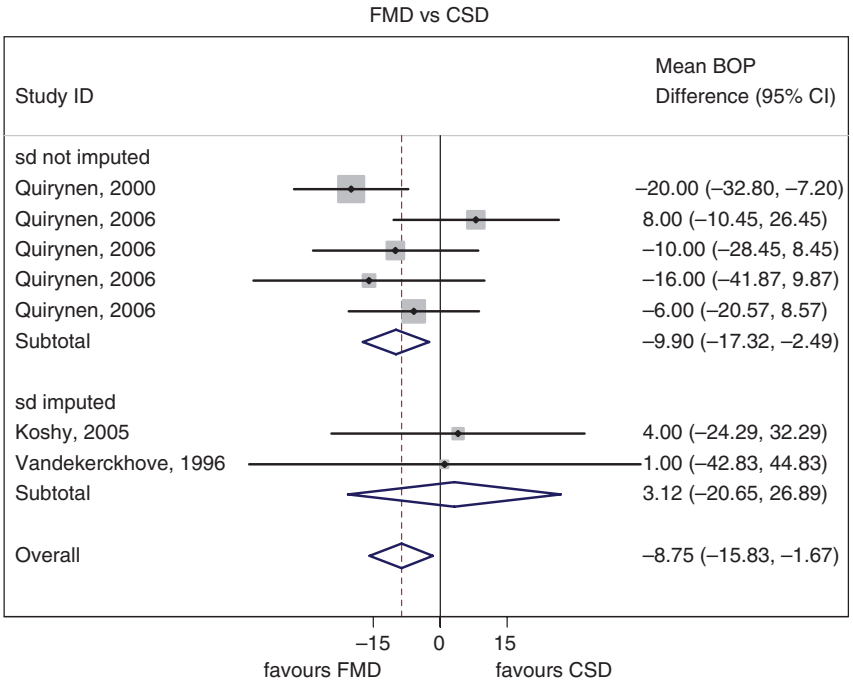

Fig. 9. Weighted mean Difference (95% CI) of BOP between FMD and CSD. *p*-value for heterogeneity: 0.165I^2: 38.4% (SD not imputed studies); 0.910I^2 0% (SD imputed studies).

and to 0.68 mm (0.43, 0.92) ($p <$ 0.0001) for deep pockets ($\geqslant$7 mm), respectively (Fig. 17).

FMD (with the use of antiseptics) versus *FMSRP (without the use of antiseptics)*

Based on the three studies indicated (# 4, 12, 16), the weighted mean difference (95% CI) between FMD and FMSRP amounted to – 0.26 mm (– 0.48, – 0.05) ($p = 0.016$) favouring FMSRP (Fig. 18).

Sub-analysis for single- or multi-rooted teeth was based on two studies only. For single-rooted teeth, the weighted mean difference (95% CI) between FMD and FMSRP amounted to – 0.25 mm (– 0.60, 0.11) (NS) and to – 0.41 mm (– 0.71, – 0.12) ($p =$ 0.006) for multi-rooted teeth, respectively (Fig. 19).

Based on the three studies mentioned above, the weighted mean difference (95% CI) between FMD and FMSRP amounted for moderate pockets (5–6 mm) to – 0.19 mm (– 0.46, 0.08) (NS) and to – 0.39 mm (– 0.75, – 0.04) ($p = 0.030$) for deep pockets ($\geqslant$7 mm), respectively (Fig. 20).

Changes in the subgingival microbiota

Owing to the heterogeneity of the various microbiological techniques applied in the studies, no meta-analyses could be performed for microbiological parameters.

FMD (with the use of antiseptics) versus *CSD*

Based on four studies (# 6, 7, 8, 16) totalling 77 patients, the subgingival microbiota before and after either FMD or CSD was evaluated. For both clinical approaches, the subgingival microbiota improved substantially from baseline to the first evaluation as documented by both dark-field microscopy and cultivating presumptive periodontal pathogens. The improvements in the FMD patients when compared with the improvements with CSD patients were more favourable for FMD in two studies (# 6, 7, Bollen et al. 1996, Quirynen et al. 1999) applying dark-field microscopy as well as cultural data, and another study from the same research group (# 8, De Soete et al. 2001) confirmed similar results when using DNA–DNA hybridization. In contrast, one study applying polymerase chain

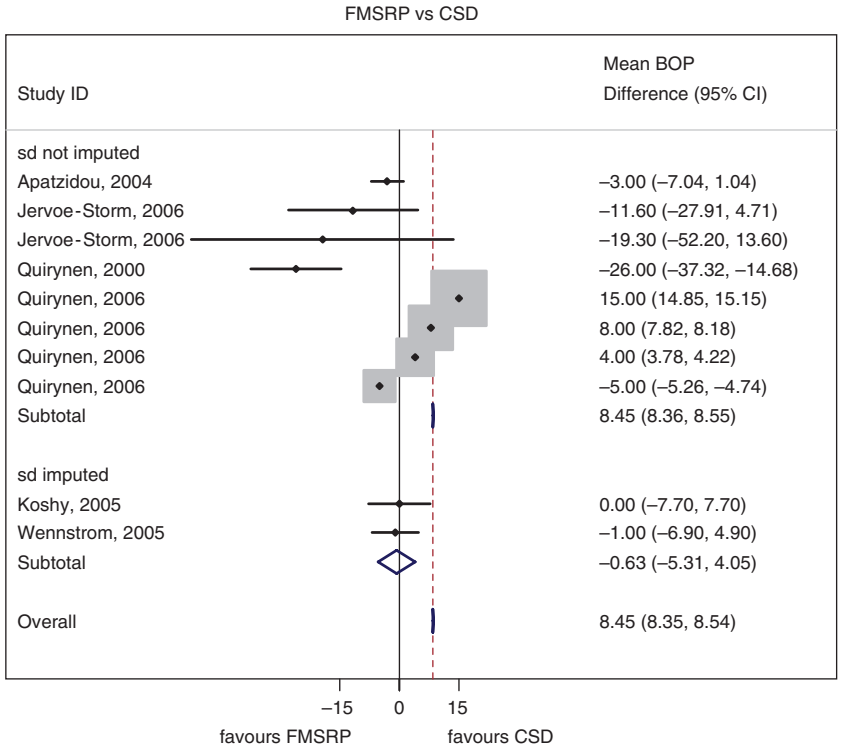

Fig. 10. Weighted mean Difference (95% CI) of BOP between FMSRP and CSD. *p*-value for heterogeneity: 0.000I^2: 100% (SD not imputed studies); 0.840I^2 0% (SD imputed studies).

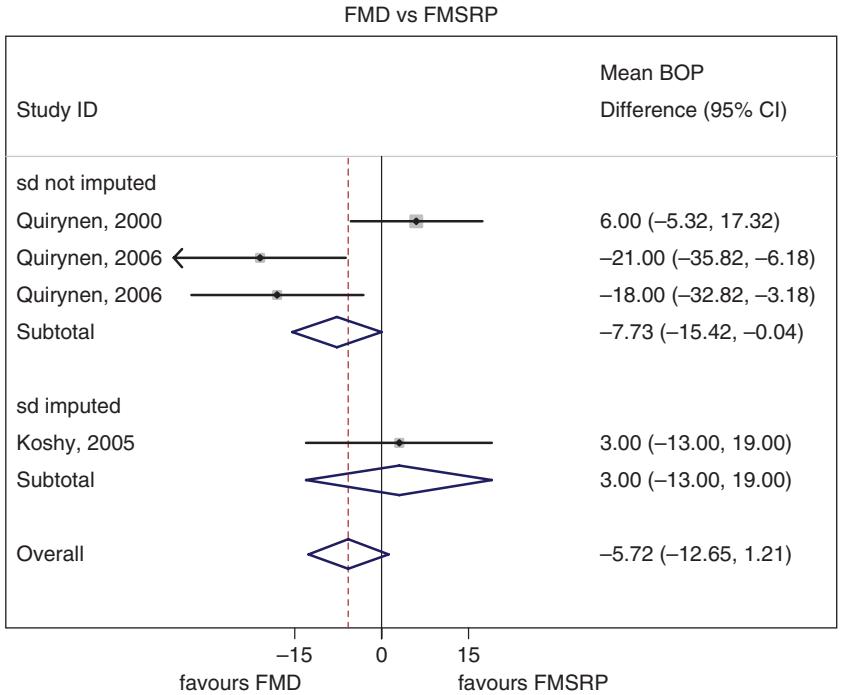

Fig. 11. Weighted mean Difference (95% CI) of BOP between FMD and FMSRP. *p*-value for heterogeneity: 0.005I^2: 81.1% (not imputed); 0.007I^2 75.0% (overall).

reaction (PCR) amplification (# 16, Koshy et al. 2005) failed to yield significant differences in the microbiological improvements between FMD and CSD. The more favourable reductions in the FMD patient cohort were generally maintained up to 8 months in the studies performed at the University of Leuven as opposed to the patients treated by CSD where a rebound of periodontal pathogens was observed.

FMSRP (without the use of antiseptics) versus *CSD*

Based on four studies (# 9, 10, 12, 16) totalling 108 patients, the subgingival microbiota before and after either FMSRP or CSD was evaluated. Again, for both clinical approaches, the subgingival microbiota improved from baseline to the first evaluation as documented by PCR amplification for presumptive periodontal pathogens. The improvements, however, did not differ between FMSRP and CSD except for *Treponema denticola*. The reductions in pathogens were maintained for 6 months with either clinical approach (# 9, Apatzidou et al. 2004). With two different microbiological identification methods [PCR and real-time (RT)-PCR], no differences between the microbiological results of FMSRP and CSD for either short-term or longer-term reductions in pathogens could be demonstrated (# 10, 16, Jervøe-Storm et al. 2007, Koshy et al. 2005).

On the other hand, the research group of the University of Leuven presented significantly greater reductions in pathogens following FMSRP than following CSD as documented by dark-field microscopy and culturing (# 12, Quirynen et al. 2000).

FMD (with the use of antiseptics) versus *FMSRP (without the use of antiseptics)*

Based on two studies (#12, 16) totalling 48 patients, the subgingival microbiota before and after either FMD or FMSRP was evaluated. For both clinical modalities, the subgingival microbiota improved from baseline to the first evaluation as documented by dark-field microscopy, cultivating presumptive periodontal pathogens and RT-PCR. No differences between the microbiological results of FMD and FMSRP for either short-term or longer-term reductions in pathogens could be demonstrated (# 12, 16, Quirynen et al. 2000, Koshy et al. 2005).

Discussion

The focused question of this systematic review was: ‘‘In patients with chronic

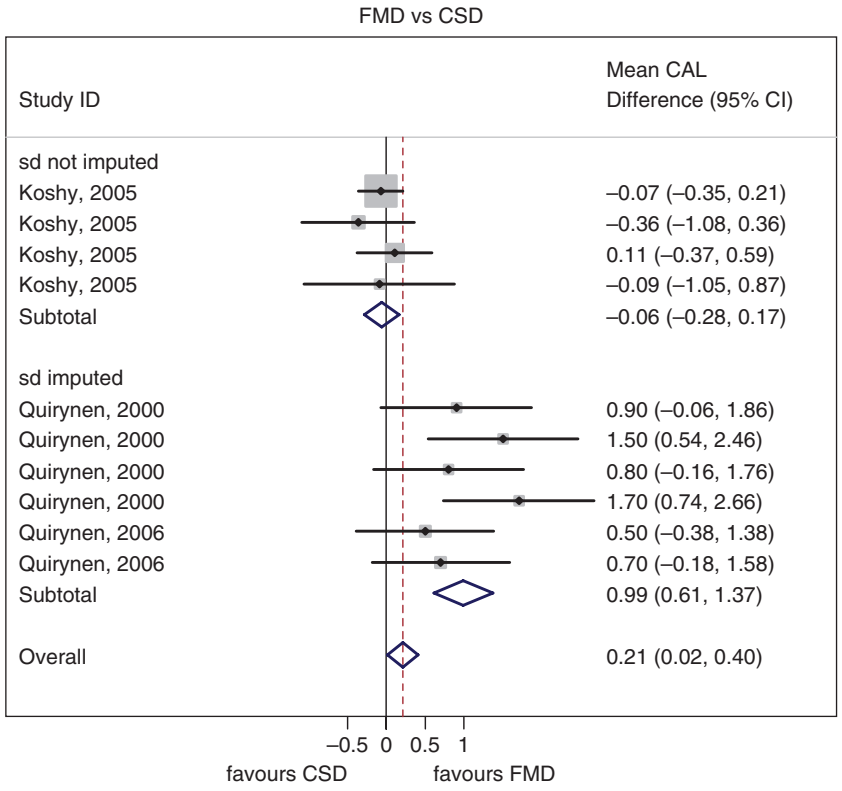

Fig. 12. Weighted mean Difference (95% CI) of CAL gain between FMD and CSD. *p*-value for heterogeneity: 0.765I^2: 0% (SD not imputed studies); 0.421I^2 0% (SD imputed studies).

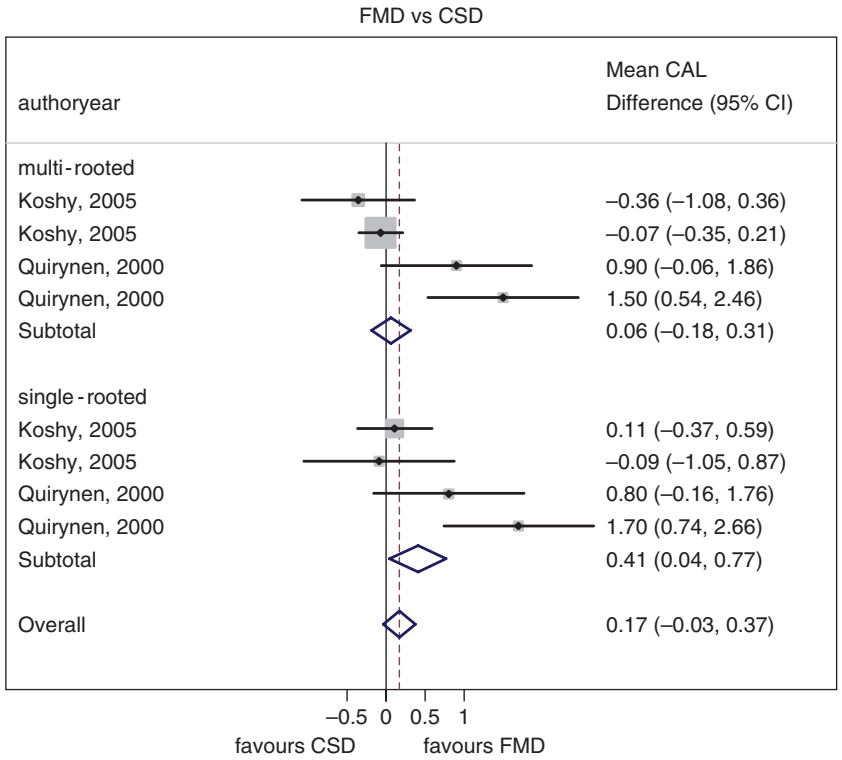

Fig. 13. Weighted mean Difference (95% CI) of CAL gain between FMD and CSD, stratified based on single- and multi- rooted teeth. *p*-value for heterogeneity: 0.004I^2: 77.9% (multi-rooted); 0.018I^2 70.1% (single-rooted).

periodontitis, what are the clinical and microbiological outcomes of Full Mouth Disinfection (FMD) *versus* Conventional Staged Debridement (CSD) after a follow-up period of at least six months?'' Following the literature searches, another clinical protocol that did not include the use of antiseptics for the FMD concept became apparent and was included in the review as the FMSRP concept. Adequate information was available to separate the outcomes for the three modalities and, hence, to test the additional effects of antiseptic regimes within the concept of FMD.

While a total number of 12 studies were identified by the search processes (five reporting solely clinical, five reporting microbiological and two reporting both clinical and microbiological data), the number of available RCTs for the pure FMD, the FMSRP and the CSD concepts were four, six and seven, respectively. This allowed the direct comparison of the effects of FMD *versus* CSD based on four articles, the direct comparison of the effects of FMSRP *versus* CSD based on six articles and the direct comparison of the effects of FMD *versus* FMSRP based on three articles. Owing to the homogeneity of the clinical outcomes, meta-analyses were performed. Data from patient cohorts not classified as ''chronic periodontitis'' were excluded from the analyses.

The primary outcome variable of interest was the differences in the reduction in PPD at the end of the studies. FMD resulted in a significantly greater difference of PPD, when compared with CSD. Likewise, FMSRP yielded significantly greater differences of PPD than did CSD. In contrast, the comparison of the FMD concept with and without the application of antiseptics did not result in any differences in the PPD at the end of the studies.

Comparing FMD with CSD, it has to be realized that the ΔPPD were significantly greater only for single-rooted teeth and were more pronounced for deeper PPD. The fact that the differences reached not >0.5 mm in these particular sites renders the FMD concept to be of questionable clinical value as a routine to be preferred in daily practice over the CSD concept. Even though the single-rooted teeth with deep pockets may benefit from being instrumented under the FMD concept, the instruction in meticulous oral hygiene practices that should precede the instrumentation would

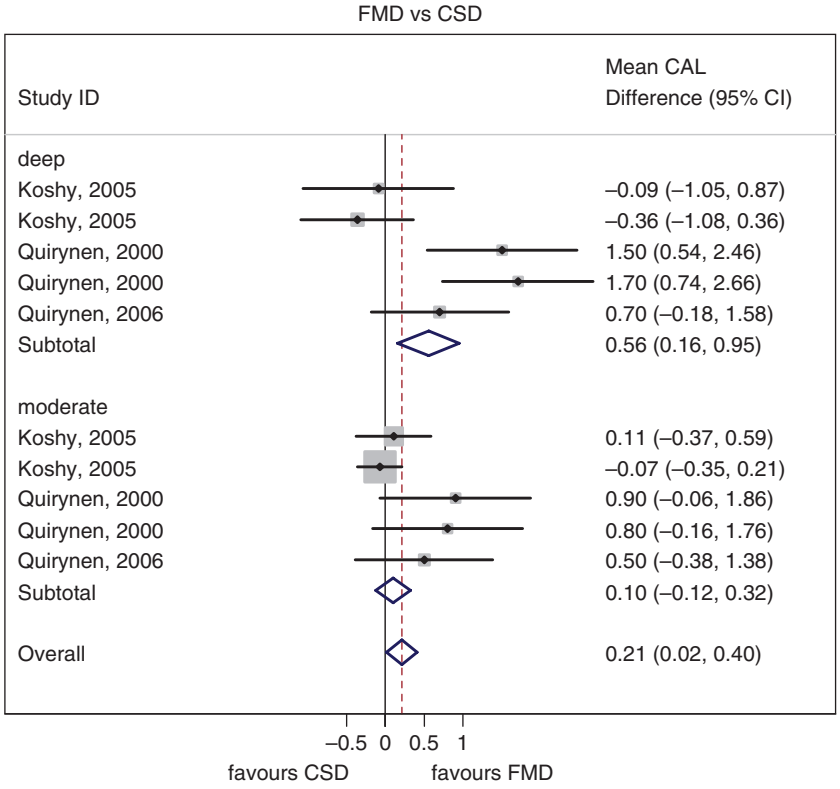

Fig. 14. Weighted mean Difference (95% CI) of CAL gain between FMD and CSD, stratified based on moderate (5–6 mm) and deep (⩾7 mm) pockets. *p*-value for heterogeneity: 0.002I^2: 76.6% (deep); 0.144I^2 41.7% (moderate).

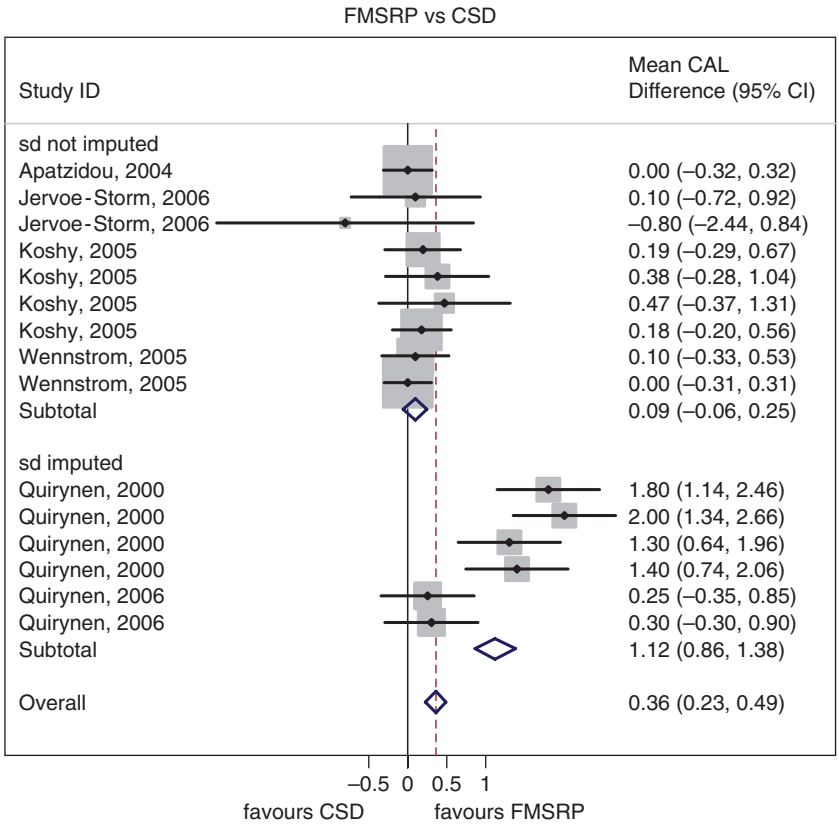

Fig. 15. Weighted mean Difference (95% CI) of CAL gain between FMSRP and CSD. *p*-value for heterogeneity: 0.885I^2: 0% (SD not imputed studies); 0.000I^2 81.7% (SD imputed studies).

require a staged approach (Söderholm & Egelberg 1982, Söderholm et al. 1982, Glavind 1990).

Obviously, the adjunctive use of chlorhexidine as an antiseptic appeared to be of limited value when comparing the ΔPPD of FMD *versus* CSD and the FMSRP *versus* CSD. While the first comparison resulted in a 0.27 mm greater reduction in favour of FMD, the second comparison only yielded a difference in reduction of 0.13 mm favouring FMSRP, a borderline relevant preference in clinical practice. Moreover, the comparison of the ΔPPD of the FMD with the FMSRP concept showed no difference between the two treatments. This, in turn, means that the adjunctive application of chlorhexidine or any other antiseptic most likely failed to have an effect on ΔPPD. Chlorhexidine may, however, be effective in depleting the supragingival bacterial colonization (Löe & Schiøtt 1970, Brecx 1997). In studies on the subgingival irrigation using chlorhexidine as an agent, permanent effects on the subgingival microbiota could not be established (Wennström 1992).

When analysing the microbiological results of the studies included in the present systematic review, no superior reductions in either bacterial load or specific presumptive periodontal pathogens were identified for any of the three modalities when modern microbiological identification methods, such as PCR or RT-PCR, were used. However, one laboratory (de Soete et al. 2001) was able to document higher reductions of ''red'' and ''orange'' complex bacteria applying DNA–DNA hybridization techniques. The controversy in the results of the seven microbiological studies may only be explained on the basis of methodological variability. The three laboratories applying PCR (Apatzidou et al. 2004, Koshy et al. 2005, Jervøe-Storm et al. 2007) failed to reveal any significant differences in the subgingival microbiota between FMSRP and CSD, and one laboratory (Koshy et al. 2005) assessed FMD in addition to FMSRP and CSD without any difference in microbial recolonization.

The significant differences in microbial recolonization following FMD and in one study following FMSRP presented by the laboratory of the University of Leuven are dificult to interpret in the light of the results presented by the remainder of the research community. Earlier studies applied culturing

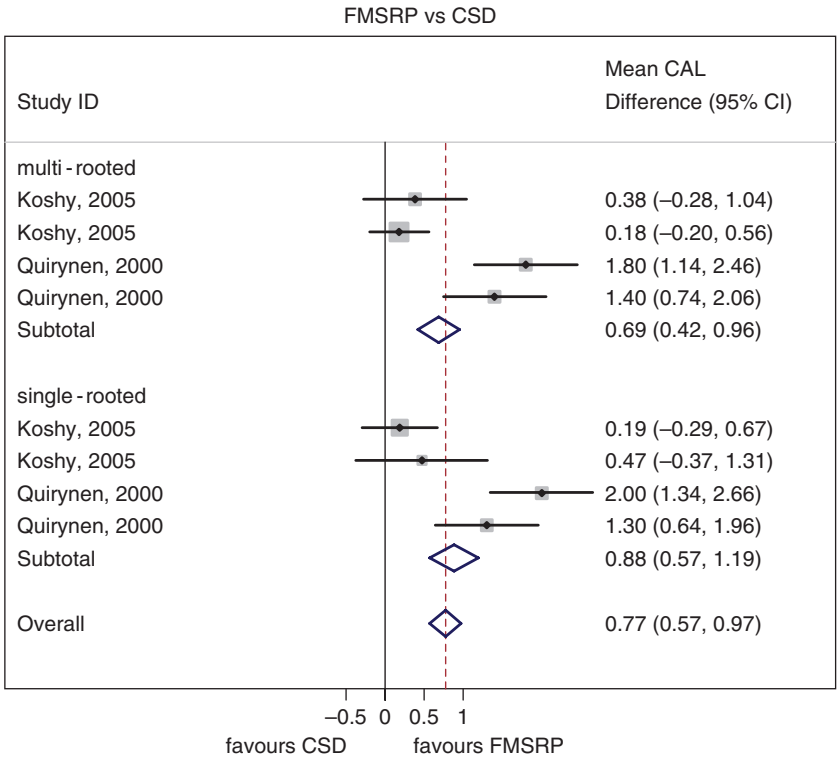

Fig. 16. Weighted mean Difference (95% CI) of CAL gain between FMSRP and CSD stratified based on single- and multi-rooted teeth. *p*-value for heterogeneity: 0.000I^2: 87.1% (SD not imputed studies); 0.000I^2 86.1% (SD imputed studies).

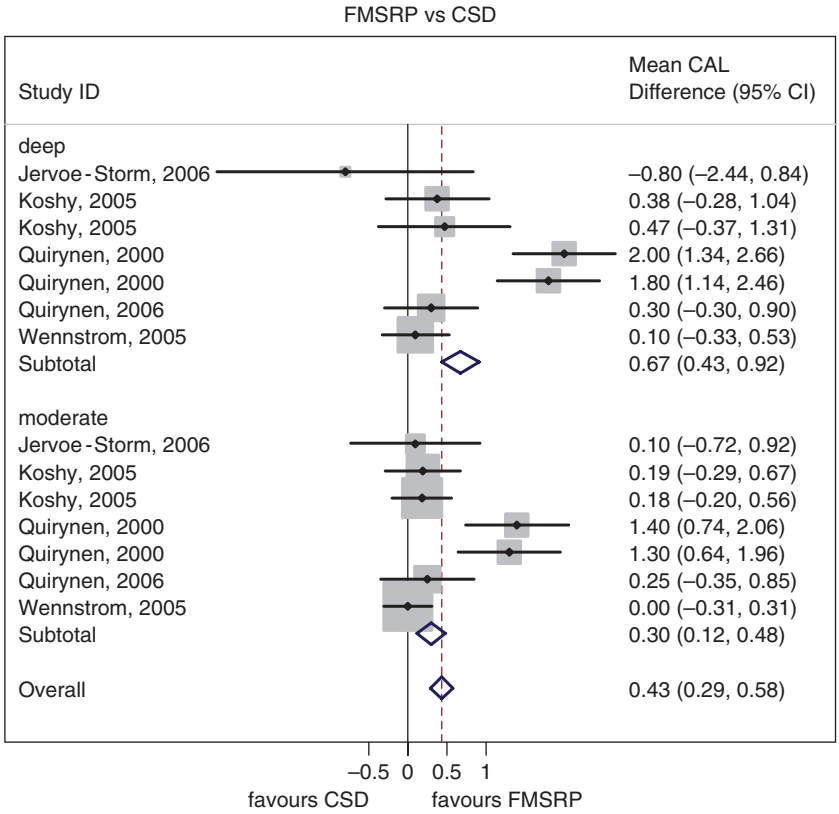

Fig. 17. Weighted mean Difference (95% CI) of CAL gain between FMSRP and CSD, stratified based on moderate (5–6 mm) and deep ($\geqslant$7 mm) pockets. *p*-value for heterogeneity: 0.000I^2: 84.8% (deep); 0.000I^2 75.2% (moderate).

techniques for bacterial identification (Bollen et al. 1998, Quirynen et al. 1999, 2000). It is evident that results with those techniques may be even harder to reproduce because sampling, transportation to the laboratory, processing in the anaerobic atmosphere and disruption of the samples are crucial issues requiring standardization and calibration of methods among laboratories (Mombelli et al. 1989). On the other hand, using DNA–DNA hybridization, standardization of the time elapsing between sampling and processing of the microbiological samples may be of importance (Katsoulis et al. 2005 a, b). Hence, the results obtained with various microbiological identification techniques are extremely difficult to compare, a fact that led to the decision of not meta-analysing microbiological results in the present systematic review. The parallel comparison of cultural microbiological data with RT-PCR data (Jervøe-Storm et al. 2005) revealed excellent agreement only for *Aggregatibacter actinomycetemcomitans* and *Porphyromonas gingivalis*, but fair agreement for *Tannerella forsythia* and poor agreement for *Fusobacterium nucleatum* and *Prevotella intermedia*. Another study performed by the same research group (Jervøe-Storm et al. 2007) analysed the microbiological data for short- and long-term effects of FMSRP and CSD on the subgingival microbiota on day 1 and 1, 2, 4, 8, 12,and 24 weeks. If the concept of FMSRP was to prevent recolonization of already-instrumented sites, this study should reveal significant reductions following FMSRP in the microbiota during at least the first 12 weeks. However, no such significant differences for any of the microbiological parameters could be demonstrated.

The two additional parameters of interest in the studies of the present systematic review included reduction in the percentage of BOP sites and changes in clinical attachment levels (ΔCAL). With very few exceptions, both parameters confirmed the results obtained for the primary outcome variable (ΔPPD).

Significantly higher BOP reductions were revealed for FMD and FMSRP, respectively, when compared with the CSD concept. These differences, however, were very small (8.75% for FMD and 8.45% for FMSRP) and may not be of any clinical relevance. Moreover, no differences were demonstrated between

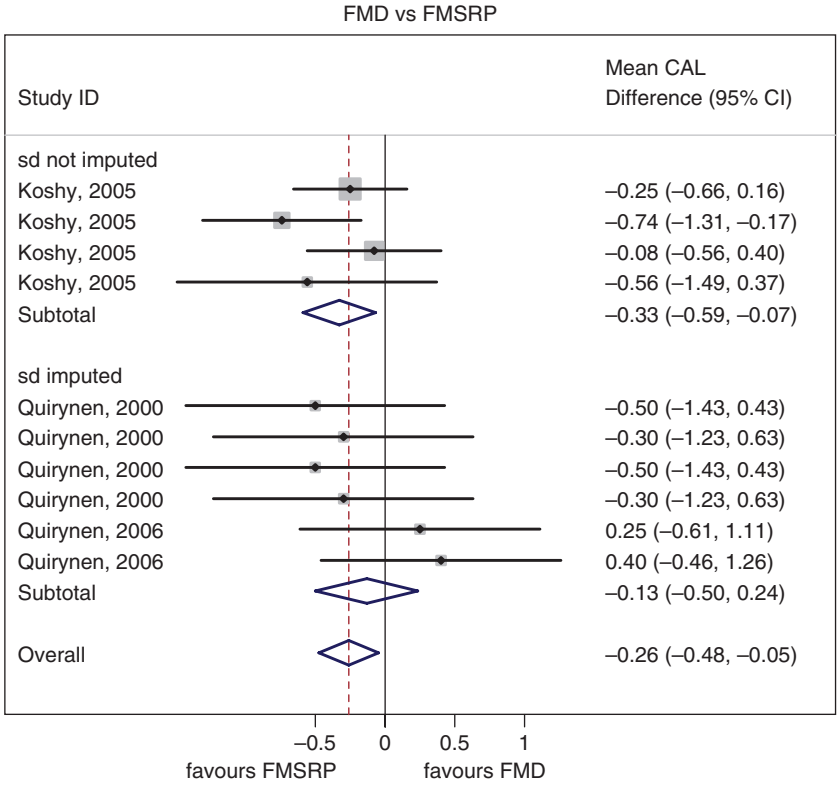

Fig. 18. Weighted mean Difference (95% CI) of CAL gain between FMD and FMSRP. *p*-value for heterogeneity: 0.328I^2: 12.9% (SD not imputed studies); 0.594I^2 0% (SD imputed studies).

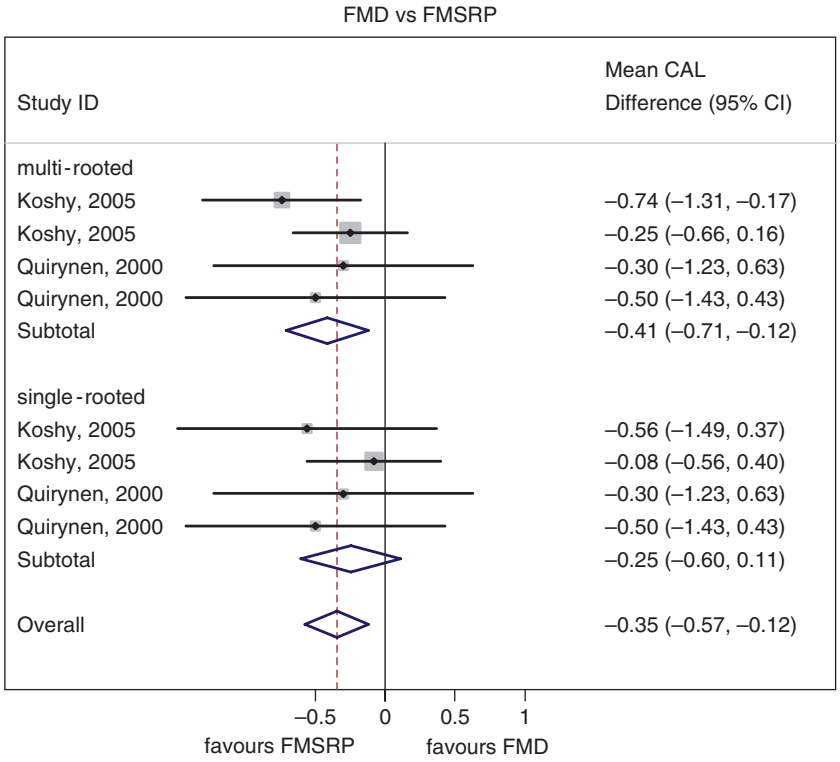

Fig. 19. Weighted mean Difference (95% CI) of CAL gain between FMD and FMSRP, stratified based on single- and multi-rooted teeth. *p*-value for heterogeneity: 0.575I^2: 0% (SD not imputed studies); 0.753I^2 0% (SD imputed studies).

the treatment modalities when single-rooted teeth were compared with multi-rooted teeth or sites of moderate to those of deep PPD. This is owing to the small number of studies and the small sample sizes within the studies reporting on this parameter and hence, the limited amount of data available for the analysis. The direct comparison of the reductions of BOP percentages applying the FMD concept with and without the use of antiseptics was only 5.72% and did not show any statistically significant difference. Again, such reductions in BOP may only represent inter-examiner variability, because BOP assessments are substantially dependent on the pressure applied to the periodontal probe (Lang et al. 1991). No data on reproducibility of intra- and inter-examiner variability were reported for any of the studies included in the present systematic review.

CAL gains were significantly greater (0.21 mm) for FMD than for CSD. Again, this difference is hardly clinically relevant and did not reach significance for multi-rooted teeth and moderate PPD (5–6 mm) analysed separately. The comparison between the FMSRP and CSD concepts yielded 0.36 mm in favour of FMSRP, and the direct comparison of the FMD with and without the use of antiseptics (FMSRP) showed a difference in favour of FMSRP of 0.26 mm in ΔCAL. This significant difference is in contrast to the expected tendency and questions the values of studies reporting on non-calibrated CAL measurements.

The changes in PPD and CAL gains revealed in the present systematic review have to be put into perspective with changes reported previously in clinical trials on periodontal therapy, especially the effects of the initial (hygienic) phase of periodontal care (e.g. Morrison et al. 1980, Pihlstrom et al. 1983). PPD reductions of approximately 1.0 mm for pockets with PPD of 4–6 mm and approximately 2.2 mm for pockets with PPD of $\geqslant$7 mm would have to be expected with CSD. In the light of these expected reductions, the additional benefits of FMD or FMSRP are small and, hence, are hardly relevant from a clinical point of view.

Most recently, another systematic review (Eberhard et al. 2008) comparing the clinical effects of the treatment modalities discussed in the present paper was performed through the Cochrane Collaboration Oral Health Group. In this systematic review, no

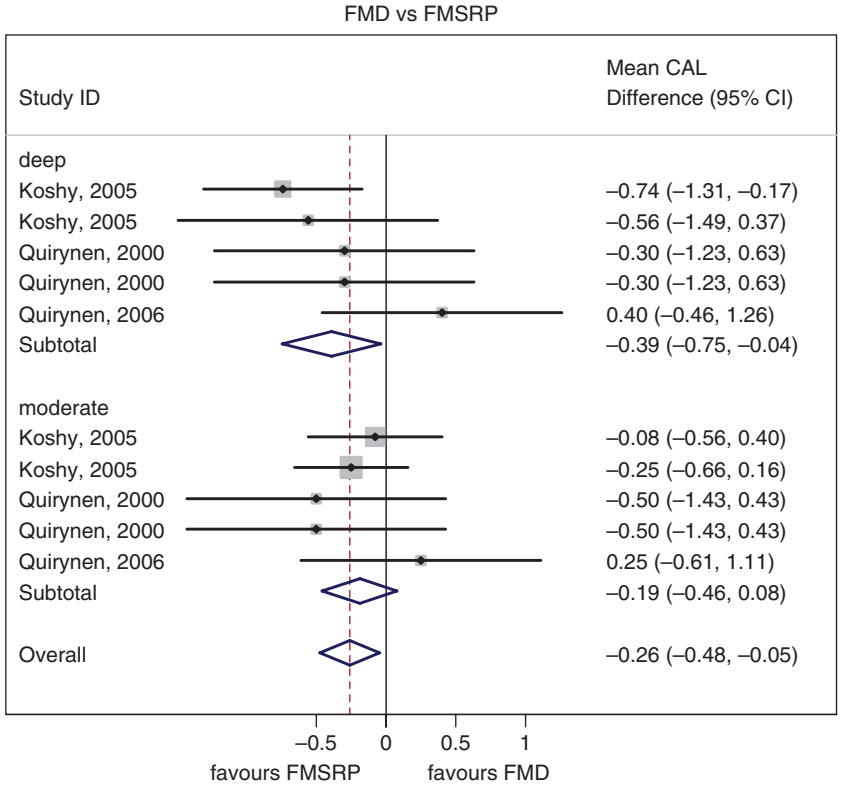

Fig. 20. Weighted mean Difference (95% CI) of CAL gain between FMD and FMSRP, stratified based on moderate (5–6 mm) and deep ($\geqslant$7 mm) pockets. *p*-value for heterogeneity: 0.296I^2: 18.7% (SD not imputed studies); 0.708I^2 0% (SD imputed studies).

significant differences between FMSRP and CSD for ΔPPD were reported. Only minor differences in CAL gain were demonstrated for FMD when compared with CSD in single-rooted moderately deep pockets (5–6 mm). More CAL gain was revealed for FMSRP than for FMD in deep multi-rooted teeth. Slightly more BOP% reductions were found for FMD than for FMSRP, in moderate pockets of single-rooted teeth. The authors concluded no advantages of FMSRP against CSD. Furthermore, very limited evidence for little additional benefits of FMD in comparison with CSD were stated and, hence, FMSRP as well as CSD may be considered as evidence-based treatment variations for chronic periodontitis patients.

In conclusion and in agreement with the recently performed systematic review (Eberhard et al. 2008), FMD or FMSRP do not provide clinically relevant advantages over the conventional quadrant-wise staged debridement. Although statistically significant differences between FMD and CSD as well as between FMSRP and CSD were found for some PPD reductions and CAL gains, they were inconsistent and small in the light of the documented changes of 1–2 mm for the cause-related phase of periodontal therapy. Hence, all three treatment approaches may, without any preference, be recommended for debridement in the cause-related phase of periodontal therapy in patients with chronic periodontitis. No conclusions could be made about the different microbiological outcomes reported, mainly due to the differences in the microbiological techniques utilized.

Acknowledgements

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Clinical Relevance

Scientific rationale for the study: FMD propagated during the last decade was evaluated in a systematic review against CSD. Also, FMSRP was compared with FMD and CSD. *Principle findings*: The meta-analyses yielded either no differences in clinical outcomes (PPD, BOP, and CAL) between the debridement protocols or favoured FMD slightly . *Practical implications*: Because the most significant effect in PPD and BOP reductions and CAL gains is attributable to systematic debridement *per se* (1.0–2.2 mm), the additional benefits of FMD are of such a small magnitude that all three protocols of FMD, FMSRP and CSD can be recommended for the initial phase of periodontal therapy.