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Subgingival Instrumentation for Treatment of Periodontitis. A Systematic Review.

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Abstract

Objectives: To evaluate the efficacy of subgingival instrumentation (PICOS-1), sonic/ultrasonic/hand instruments (PICOS-2) and different subgingival instrumentation delivery protocols (PICOS-3) to treat periodontitis.

Methods: Systematic electronic search (CENTRAL/MEDLINE/EMBASE/SCOPUS/LILACS) to March 2019 was conducted to identify randomized controlled trials (RCT) reporting on subgingival instrumentation. Duplicate screening and data extraction were performed to formulate evidence tables and meta-analysis as appropriate.

Results: As only one RCT addressed the efficacy of subgingival instrumentation compared to supragingival cleaning alone (PICOS-1), baseline and final measures from 11 studies were considered. The weighted pocket depth (PD) reduction was 1.7 mm (95%CI: 1.3-2.1) at 6/8 months and the proportion of pocket closure was estimated at 74% (95%CI: 64-85). Six RCTs compared hand and sonic/ultrasonic instruments for subgingival instrumentation (PICOS-2). No significant differences were observed between groups by follow-up time point or category of initial PD. Thirteen RCTs evaluated quadrant-wise vs full-mouth approaches (PICOS-3). No significant differences were observed between groups irrespective of time-points or initial PD. Five studies reported patient-reported outcomes, reporting no differences between groups.

Conclusions: Nonsurgical periodontal therapy by mechanical subgingival instrumentation is an efficacious means to achieve infection control in periodontitis patients irrespective of the type of instrument or mode of delivery. Prospero ID:CRD42019124887

Introduction

Periodontitis is a chronic multifactorial inflammatory disease associated with dysbiotic plaque biofilms and characterized by progressive destruction of the tooth-supporting apparatus which may result in tooth loss. In the 2017 World Workshop on the Classification of Periodontal and Peri-implant Diseases and Conditions the lack of available evidence supporting the distinction between aggressive and chronic forms of periodontitis was highlighted. However, it was recognized that a substantial variation in terms of extent and severity of the disease may be observed. In addition, population subgroups may be identified presenting with distinct disease trajectories suggesting differences in terms of susceptibility and exposure. As a result, a new classification was proposed which included staging (4 disease stages) to describe extent and complexity of the disease and grading (3 grades) to capture biological features and risk for further progression. Grading should also implement the analysis of potentially poorer outcomes of treatment (Papapanou et al., 2018).

The main goal of the treatment of patients suffering from periodontitis is the establishment of adequate infection control, i.e. reduction of the bacterial load below individual threshold levels of inflammation/disease. Health behaviour strategies to facilitate patient motivation targeting high-level self-performed supra-gingival plaque control and management of lifestyle habits such as smoking are key in addressing the vital patient role in non-surgical therapy (Ramseier & Suvan, 2015). Supplemental to patient self-care, subgingival instrumentation serves the purpose of altering the subgingival ecological environment through disruption of the microbial biofilm and removal of hard deposits, i.e. periodontal debridement, thereby suppressing soft tissue inflammation (Heitz-Mayfield & Lang, 2013; Jepsen, Deschner, Braun, Schwarz & Eberhard, 2011). A reasonable endpoint of non-surgical treatment should include shallow pocket depth (PD) and absence of clinical signs of inflammation, i.e. oedema and bleeding on probing (BOP). Nevertheless, mean values of probing pocket depth reduction and clinical attachment gain are the most commonly reported outcomes in studies. An ideal endpoint of therapy, however, should be clinically meaningful with tangible benefits for the patient. Endpoints must also be considered in relation to the goal of therapy. The question of the most adequate outcomes to evaluate non-surgical periodontal therapy has been discussed in the literature (Hujoel, 2004; Tomasi & Wennström, 2017).

The efficacy (as established in strictly defined research setting to minimise confounding factors) of nonsurgical subgingival instrumentation as part of periodontal treatment is well documented and has been summarized in several reviews (Hallmon & Rees, 2003; Herrera, 2016; Smiley et al., 2015; Suvan, 2005; Tomasi & Wennström, 2009; Tunkel, Heinecke, & Flemmig, 2002; Van

der Weijden & Timmerman, 2002). There is, however, a paucity of data addressing effectiveness (established in a real world setting such as clinical practice with potential additional confounding factors) of nonsurgical interventions. In addition, a number of different approaches including adjunctive measures and/or novel technologies have been suggested but not fully validated.

Thus, various instruments may be appropriate for subgingival instrumentation, demonstrating differences in the removal of soft and hard subgingival deposits (Lea, Landini, & Walmsley, 2003; Leknes, Lie, Wikesjo, Bogle, & Selvig, 1994). Ultrasonic devices, when compared to hand instruments, remove less root/tooth structure and cause less soft tissue trauma (Schmidlin, Beuchat, Busslinger, Lehmann, & Lutz, 2001). It has been suggested that they are less operator-dependent and require less treatment time, while resulting in a rougher root surface (Breininger, O'Leary, & Blumenshine, 1987). In contrast, hand instrumentation may result in smoother tooth surfaces and may remove more calculus deposits (Rateitschak-Pluss, Schwarz, Guggenheim, Duggelin, & Rateitschak, 1992). For a comprehensive review on factors influencing calculus removal, see Jepsen et al. (2011). In clinical practice, treatment often includes a combination of instruments. An objective of the present review is to address the efficacy of any type of instrument in terms of treatment outcomes.

Another objective of this review is to evaluate the potential impact of mode of delivery of subgingival instrumentation without adjunctive antiseptics. Traditionally, sessions for mechanical instrumentation were scheduled with intervals of one week between appointments in order to instrument one segment of the entire dentition. This staged treatment approach allows for meticulous treatment of the target sites with the possibility for repeated re-enforcement of patients' self-performed infection control. An alternative to the conventional approach, a full-mouth instrumentation protocol, was first described by Quirynen and co-workers in 1995 and comprised two sessions of scaling and root planing within 24 hours with the use of adjunctive antiseptics (Quirynen et al., 1995).

The aim of the present systematic review was to provide a robust critical appraisal of the evidence of the efficacy of subgingival instrumentation for the treatment of periodontitis, the efficacy of sonic/ultrasonic/hand instruments and the efficacy of different delivery protocols for subgingival instrumentation in terms of timing. In order to address the aim, PICOS criteria were set as outlined in Table 1.

Table 1. PICOS Criteria

Based upon the outlined PICOS criteria, the three focused questions of the systematic review were:

PICOS Question 1

In patients with periodontitis, what is the efficacy of subgingival instrumentation performed with hand or sonic/ultrasonic instruments in comparison with supragingival instrumentation or prophylaxis in terms of clinical and patient reported outcomes?

PICOS Question 2

In patients with periodontitis, what is the efficacy of nonsurgical subgingival instrumentation performed with sonic/ultrasonic instruments compared to subgingival instrumentation performed with hand instruments or compared to the subgingival instrumentation performed with a combination of hand and sonic/ultrasonic instruments in terms of clinical and patient reported outcomes?

PICOS Question 3

In patients with periodontitis, what is the efficacy of full mouth delivery protocols (within 24 hours) in comparison to quadrant or sextant wise delivery of subgingival mechanical instrumentation in terms of clinical and patient reported outcomes?

Material & Methods

This systematic review protocol was registered in PROSPERO on 22 February 2019 with ID no. CRD42019124887. Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines were followed in reporting this review (Moher, Liberati, Tetzlaff, & Altman, 2009). A PRISMA statement is attached to follow the reporting of this systematic review (Appendix).

Eligibility Criteria

Studies were eligible for inclusion in the review if they reported on individuals from 18 years onward suffering from periodontitis. All forms of periodontitis were included, excluding gingivitis,

periodontitis associated with systemic diseases or conditions or specific syndromes. Studies with unclear reporting of periodontal case definition were excluded.

Interventions and comparisons eligible for inclusion varied according to PICOS question. PICOS 1 included nonsurgical subgingival mechanical instrumentation compared to supra-gingival prophylaxis or instrumentation. PICOS 2 included nonsurgical subgingival instrumentation performed with sonic/ultrasonic instruments compared to the same performed with hand instruments or a combination of sonic/ultrasonic and hand instruments. PICOS 3 included nonsurgical mechanical subgingival instrumentation performed with full-mouth single visit protocols with or without time restriction compared to the same performed in multiple sessions according to quadrant or sextant sub-division of the mouth. Studies with unclear intervention or comparison were excluded as well as any intervention or comparison groups reporting use of adjunctive chemical therapies (local or systemic).

Studies reporting the primary outcome of reduction in mean probing pocket depth (PD) or secondary outcomes of number or proportion of pockets closed, changes in clinical attachment level (CAL), and changes of percentage bleeding on probing (BOP) were included. Studies reporting patient level of analysis or site level analysis with multilevel or GEE approaches were included with those reporting site level analysis only excluded.

Only randomised controlled trials with at least 3 months of post treatment follow-up were eligible for inclusion. Articles published in languages other than English were excluded due to time constraints.

Search Methods

Preliminary electronic searches designed to locate possible review articles, narrative and systematic were conducted to facilitate development of the electronic search strategy. The strategy was formulated using a combination of controlled vocabulary (MeSH and free text terms), then piloted to confirm high sensitivity over high precision in search results in order to maintain a broad search. The search strategy used consistent terms customised according to each database a priori and included English language restriction. The search strategy for OVID Medline is outlined in Table 2 as an example. Electronic databases searched up to 19th March 2019 with no year restrictions included Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE (OVID), EMBASE, SCOPUS, and LILACS. Hand searching of bibliographies of previously published reviews were also performed. Search results from all databases were combined and duplicates removed.

Table 2. Search strategy for OVID Medline

Study Selection

Titles and abstracts of all identified reports were independently screened by two reviewers (YL & FM) based upon the inclusion/exclusion criteria. Full text reports were obtained and assessed independently and in duplicate for studies appearing to meet the inclusion criteria or with insufficient information in the title or abstract to confirm eligibility for inclusion then confirmed by a third reviewer (JS). Disagreements following full text screening were resolved by discussion and if necessary additional reviewers were consulted (CT & JD). Excel spreadsheets were created to record information pertaining to the decision to include or exclude each article. Kappa statistic was used to assess the reviewer agreement based upon the full text screening.

Data Management

Two reviewers (JD & CT) extracted data into specifically created excel spreadsheets which were then double checked by an additional reviewer (JS). Data pertaining to study characteristics such as population, interventions, comparisons, type of outcomes reported, and study conclusions were then transferred into evidence tables to provide an overview of the included studies and available data. All data in the excel spreadsheets were reviewed to consider appropriateness for meta-analysis. Data were then entered into Stata (Stata Statistical Software: Release 15, StataCorp LLC, College Station, TX, USA) in preparation for quantitative analysis.

Outcome measures

Outcomes at 3/4 months and 6/8 months following intervention were extracted. The primary outcome was reduction of PD expressed in mm. Further consideration was given to proportion of closed pockets, defined as residual PD ≤4 mm with no bleeding after probing. Additional secondary outcomes were changes in CAL, and changes in BOP. Full mouth plaque scores were also extracted. Patient-reported outcome measures (PROMs) were also noted together with adverse events recording.

Risk of Bias Assessment

Assessment for risk of bias of all included studies was undertaken independently and in duplicate by two reviewers (YL & FM) at the time of data extraction using the ROBINS-I Tool (RoB 2.0) recommended by the Cochrane Collaboration for assessing risk of bias in randomised controlled trials (Higgins et al., 2016). Each study was graded according to five items (randomisation, deviation, missing data, outcome measurement and selective reporting) and an overall score for risk of bias was assigned.

Data Synthesis

For continuous data (changes of PD and CAL) mean values and standard deviations were used and analysed with weighted mean differences (WMD) and 95% confidence intervals (CIs). For dichotomous data (BOP and pocket closure), estimates of the effect were expressed as risk ratios (RR) and 95% CIs. The variable pocket closure was not consistently defined throughout the included studies. In the present analysis, reported data were pooled, irrespective of the individual case definition. Study-specific estimates were pooled with the random-effect model (DerSimonian & Laird, 1986) and grouped according to pocket depth (all, shallow (4-6 mm) or deep (≥7 mm)) and tooth type (all, single- or multi-rooted).

Two separate sets of analyses were performed. For PICOS questions 2 and 3, standard meta-analyses were performed using changes reported for test and control groups, respectively. As none of the selected RCTs addressed PICOS question 1, it was decided a posteriori to analyse baseline and final clinical data extracted from included and relevant studies, considering these findings to be independent of each other. Test and control arms were considered as separate studies. Therefore, the overall effect of treatment in terms of PD reduction and proportion of pocket closure was estimated. All analyses were performed with Stata (Stata Statistical Software: Release 15, StataCorp LLC, College Station, TX, USA) using the functions *metan* and *metaprop*. Statistical heterogeneity among studies was explored by the I^2 index (Higgins, Thompson, Deeks, & Altman, 2003) and Cochrane's Q statistic (p<0.1). Forest plots were used to illustrate the outcomes of the different analyses. To illustrate expected treatment effect prediction intervals (PI) were calculated (Borenstein, Higgins, Hedges, & Rothstein, 2017). Publication bias was evaluated through Funnel plots (function: *metafunnel*) and Egger's test for small-study effects (Egger, Davey Smith, Schneider, & Minder, 1997).

RESULTS

Search and screening

The combined total of references obtained from the electronic search strategy customised for each database was 13,137 citations with hand searching adding 10 citations and removal of duplicates resulting in 5033 citations to be screened. Independent screening of titles and abstracts resulted in 85 full text articles to be retrieved. Further screening of full text articles resulted in 19 articles eligible for inclusion in the review. Kappa score calculated for screening agreement was 0.93. Figure 1 summarises the screening results in the PRISMA flow diagram showing citations resulting at each step of the screening process. The final number of studies included in the review were 19 with 18 of those suitable for inclusion in one of a number of meta-analysis.

Figure 1. Search results PRISMA flow-chart

The search retrieved a large number of relevant articles together with a substantial number of irrelevant hits confirming the high sensitivity and relatively low precision of the search in accordance with the search strategy. Numerous citations excluded were related to application of the therapy in periodontal treatment protocols but were not designed to investigate the efficacy of nonsurgical subgingival instrumentation. During full text screening, 66 articles were excluded primary due to inclusion of adjunctive antimicrobial or antiseptics therapies or lack of reporting of data relevant to this review. The reasons for exclusion together with the articles excluded are summarised in Table 3.

Table 3. Excluded studies and reasons for exclusion (Reference list provided in Appendix).

Descriptive results

An overall brief summary of noteworthy study characteristics appears in Table 4. Included studies ranged in year of publication from 1988 to 2015, most were conducted within single centre university settings in European regions. Descriptive summaries of the 19 included studies highlighting specific study characteristics are presented in Table 5. Studies are listed chronologically from 1988 onward based on publication date and thereafter alphabetically within each year. The collective data from all studies indicated a benefit of sub-gingival instrumentation (PICOS 1) while none found a difference in treatment outcomes when comparing hand and

ultrasonic instruments to perform the treatment (PICOS 2). Only 1 study reported clinical outcome differences when comparing a full-mouth with a quadrant-wise approach (PICOS 3).

Table 4. Characteristics of included studies.

Table 5 Evidence Table of PICOS Characteristics of Included Studies

Risk of bias

Summarized results of the assessment of risk of bias are illustrated in Figure 2. One of the included studies was judged to be at high risk of bias and 11 studies presented with some concerns, mainly related to data analysis. Detailed information in regard to specific items in individual studies are reported in the full evidence table (Appendix).

Figure 2 Individual and summarised assessment of risk of bias for included studies

Selected studies by PICOS question

Table 6 presents an overview of relevant studies for each PICOS question, separated by subcategory (time of follow-up and pocket depth) and outcome. Feasibility of meta-analysis is depicted by colour-coding. In general, analysis of the reduction of BoP was not possible due to the lack of site-specific reporting, while patient-reported outcomes and adverse events could not be collectively assessed due to heterogeneous and inconsistent reporting. Sub analyses by tooth type (single-, multi-rooted) was not feasible based on the lack of data.

Table 6. Overview on meta-analyses performed.

PICOS question 1

One randomised controlled trial (Kapellas et al., 2013) specifically addressed PICOS question 1, i.e. the potential benefit of subgingival instrumentation over supragingival cleaning alone. In a specific patient population, the study indicated a significant benefit in terms of percentage of pocket closure at 3 months. Data on BOP reduction or patient-reported outcomes were not presented.

Considering baseline and final recordings separately, the weighted PD reduction was 1.0 mm (95%CI: 0.8; 1.3 / PI: -0.1; 2.2) at 3/4 months (9 studies) and 1.7 mm (95%CI: 1.3; 2.1 / PI: -0.2; 3.7) at 6/8 months (11 studies). The Egger's test indicated a high risk of bias. The proportion of closed pockets was estimated to be 57% (95%CI: 46; 68) and 74% (95%CI: 64; 85) at the two time points, respectively (Figure 3a-1 to 3a-4). For details on heterogeneity as evaluated by I^2 and Q statistic, see appendix.

Figure 3a. Weighted mean PD reduction and proportion of closed pockets at 6/8 months including Funnel plots.

Analysis of initially shallow sites revealed a weighted mean PD reduction of 1.5 mm (95%CI: 1.2; 1.7 / PI: 0.3; 2.7) at 3/4 months (10 studies) and 1.6 mm (95%CI: 1.3; 1.8 / PI: 0.6; 2.5) at 6/8 months (6 studies). For initially deep sites, a weighted PD reduction of 2.6 mm (95%CI: 2.2; 3.0 / PI: 0.7; 4.6) at 3/4 months (10 studies) and 2.6 mm (95%CI: 1.1; 3.1 / PI: 0.5; 4.7) at 6/8 months (7 studies) was observed (Figure 3b-1 to 3b-4).

Figure 3b. Weighted mean PD reduction for shallow and deep sites at 6/8 months including Funnel plots.

To estimate the effect of treatment on BOP, the relative reduction of patient-based scores was calculated for studies providing the data. The weighted mean reduction of BOP scores at 3/4 months, based on 9 studies, was 56.7% ±13.9. At 6/8 months the corresponding reduction, based on 8 studies, was 62.7% ±17.5.

PICOS question 2

Six randomised controlled trials (Ioannou et al., 2009; Laurell & Pettersson, 1988; Malali, Kadir, & Noyan, 2012; Obeid, D'Hoore, & Bercy, 2004; Petelin, Perkič, Seme, & Gašpirc, 2015; Wennström, Tomasi, Bertelle, & Dellasega, 2005) specifically addressed PICOS question 2, i.e. the comparison between hand and sonic/ultrasonic instruments for subgingival treatment. Meta-analysis was possible for PD reduction and CAL gain, but not for any of the other outcomes considered. No significant differences were observed between treatment groups at any time point or for different categories of initial pocket depth. Findings at 6/8 months for PD reduction and CAL gain are illustrated in Figure 4. The Egger's test did not reveal a significant risk of bias. One study reported data on site-specific reduction of BOP, not identifying any significant differences

between groups (Wennström et al., 2005). Results from the remaining analyses are presented in the Appendix (see Table 6 for guidance).

Figure 4. WMD between hand and sonic/ultrasonic instruments for PD reduction and CAL gain at 6/8 months including Funnel plots.

PICOS question 3

Thirteen randomised controlled trials (Apatzidou & Kinane, 2004; Del Peloso Ribeiro et al., 2008; Fonseca et al., 2015; Jervøe-Storm et al., 2006; Koshy et al., 2005; Loggner Graff, Asklöw, & Thorstensson, 2009; Meulman et al., 2013; Predin et al., 2014; Quirynen et al., 2006; Swierkot, Nonnenmacher, Mutters, Flores-de-Jacoby, & Mengel, 2009; Wennström et al., 2005; Zanatta et al., 2006; Zijnge et al., 2010) specifically addressed PICOS question 3, i.e. the comparison between quadrant-wise and full-mouth approaches for subgingival instrumentation. Meta-analysis was possible for the outcomes PD reduction, CAL gain and pocket closure (for details, see Table 6). No significant differences were observed between treatment groups irrespective of time point or initial pocket depth. Findings at 6/8 months for PD reduction, CAL gain and pocket closure are illustrated in Figure 5. The Egger's test did not reveal a significant risk of bias. Two studies reported site-specific reduction of BOP, indicating no significant differences between treatment groups at 3/4 (p=0.67) and 6/8 months (p=0.78) (Del Peloso Ribeiro et al., 2008; Wennström et al., 2005). Adverse events, addressed in 5 studies, were rare (1 event in each treatment group reported in one study (Predin et al., 2014)) with no differences between groups. Discomfort following instrumentation was reported in 5 studies (Apatzidou & Kinane, 2004; Del Peloso Ribeiro et al., 2008; Koshy et al., 2005; Loggner Graff et al., 2009; Wennström et al., 2005). Again, no differences between study groups was observed. In the study by Loggner Graff and co-workers, operators found the quadrant-wise approach less strenuous when compared to the full-mouth protocol (Loggner Graff et al., 2009). Findings from the remaining analyses are presented in the Appendix.

Figure 5. WMD between quadrant-wise and full-mouth approach for PD reduction and CAL gain at 6/8 months. RR for pocket closure at 6/8 months between treatment groups. Funnel plots included.

DISCUSSION

The remit of the present systematic review was to critically appraise and summarise the currently available literature with regards to (i) the efficacy of mechanical subgingival instrumentation as part of nonsurgical periodontal therapy, (ii) the potential impact of different types of instruments used for mechanical removal of soft and hard debris subgingivally and (iii) the influence of different modes of delivery of subgingival instrumentation. As the establishment of infection control (as measured by absence of clinical signs of inflammation and increased resistance to probing) is the main goal of treatment, reduction of pocket depth, both in terms of average measures as well as frequencies of *closed pockets* (probing pocket depth ≤4 mm and absence of bleeding on probing) were considered as relevant outcomes to address the research questions.

The results from this systematic review demonstrated that subgingival instrumentation is an efficacious treatment in reducing inflammation, probing pocket depth and number of diseased sites in patients affected by periodontitis. This effect was consistent, irrespective of the choice of instrument (sonic/ultrasonic vs hand) or mode of delivery (full-mouth vs quadrant). Thus, at shallow sites (4-6 mm) a mean reduction of PD of 1.5 mm can be expected at 6/8 months, while at deeper sites (≥7 mm) the mean PD reduction was estimated at 2.6 mm. In addition, an overall proportion of pocket closure of 74% at 6/8 months was observed, combined with a mean BOP reduction of 62%. Considering the extent of disease resolution, as measured in terms of pocket closure, it appears that well-performed nonsurgical periodontal therapy may limit the need of other additional/alternative treatment approaches, which may entail higher costs and patient morbidity.

The lack of randomised clinical trials addressing PICOS question 1 may not come as a surprise, given the ethical implications of such a study design. The only study that could be included adopted a 3-month delay in delivering the subgingival treatment in the control group (Kapellas et al., 2013). Other studies addressing efficacy of subgingival instrumentation were often not randomised and/or demonstrated a high risk of bias. Thus, the best option available was analysing longitudinal changes reported in studies identified for PICOS questions 2 and 3. We considered different treatment arms within the RCTs as separate units, which may have introduced weaknesses due to potential lack of independence and the inclusion of studies not

designed to answer the main question. Nevertheless, given the strict inclusion criteria and the absence of significant differences between treatment arms the approach adopted was deemed reasonable. The same approach was previously chosen by other authors facing similar problems (Van der Weijden & Timmerman, 2002).

Addressing PICOS question 2, no significant differences were observed in terms of clinical outcomes between hand and sonic/ultrasonic subgingival instrumentation. These results confirm previously published data, as summarized in previous reviews (Drisko, 2000; Krishna & De Stefano, 2016; Tunkel et al., 2002). It should be considered, however, that a variety of different instruments in terms of manufacturer, design, and technology were used in the different studies, which may have contributed to the heterogeneity among studies. In addition, clinicians may frequently combine the use of hand and power-driven instruments in their everyday work.

The third PICOS question focused on the comparison between the traditional quadrant-wise treatment approaches and full-mouth approaches to nonsurgical periodontal treatment. Results confirmed findings reported in previously published reviews (Eberhard, Jepsen, Jervøe-Storm, Needleman, & Worthington, 2015; Lang, Tan, Krahenmann, & Zwahlen, 2008), which failed to identify differences. It was therefore concluded that the choice of treatment delivery may be based on patients' preferences and other practical considerations such as medical status, tolerance for chair time or perhaps the need for repeated sessions of oral hygiene instructions. In this context, full-mouth approaches have been implicated with higher acute systemic inflammatory perturbation in the immediate post-operative period (Graziani et al., 2015). The reader should be aware that studies including adjunctive measures (e. g. antiseptic agents) were not included in the present analysis.

Analysing outcomes by initial PD (shallow or deep) and tooth category (single or multi-rooted) is in line with then new classification of periodontitis (Papapanou et al., 2018). Thus, cases classified as stage 1 or 2 are characterised by the presence of shallow pockets (≤5 mm), while stages 3 and 4 are characterised by deep probing and furcation involvement. Although not perfectly aligned in terms of thresholds for pocket depths, the present review showed that in more advanced cases, nonsurgical therapy was shown to be more efficacious in terms of PD reduction, while disease resolution, as measured by pocket closure, was less likely. Studies included in the

present review identified cases based on either chronic/aggressive periodontitis or on a minimum number of diseased teeth. None of the studies applied the case definitions suggested in 2018.

The primary variable chosen to evaluate treatment outcome was probing pocket depth reduction, which is a common choice in meta-analytical approaches. Probing pocket depth serves as a surrogate outcome variable and has been validated by its association with disease progression and tooth loss (Badersten, Nilveus, & Egelberg, 1990; Claffey & Egelberg, 1995; Lang et al., 2008; Matuliene et al., 2008; Westfelt, Rylander, Dahlen, & Lindhe, 1998). The goal of therapy, however, is to obtain shallow probing pocket depth and absence of bleeding, indicating sufficient removal of biofilm/calculus and subsequent resolution of the inflammatory lesion. Therefore, the present review considered pocket closure as an important component to evaluate treatment efficacy. The parameter, however, was not consistently reported and defined in different ways, i.e. with or without the measure of BOP. Future research should highlight the frequency of pocket closure.

The follow-up in the included studies rarely extended beyond 6 months, which may be considered short. It should be remembered, however, that nonsurgical therapy is part of an overall treatment strategy, constituted from many different phases, each of them needing a clinical evaluation at an appropriate follow-up interval after its completion (Kieser, 1994). In addition, there was an obvious variation between studies in terms of (i) follow-up, (ii) treatment strategy, (iii) self-performed infection control and (iv) distribution of modifying factors. However, the questions highlighted in the present review were addressed by direct comparisons within studies adapting consistent study protocols. Thus, meta-analyses were based on differences between groups.

The external validity of the data reported in the studies included in the present review may be discussed. While the overall risk of bias was found to be low for the vast majority of studies, most were institutional, performed in well-controlled environments and patient samples. Therefore, the present review probably describes efficacy rather than effectiveness of the intervention. It should also be noted that some studies were designed to investigate different primary outcomes than those addressed in the PICOS questions. The reader should also be aware that several of the relevant studies were conducted prior to the development of instruments available today, i.e. thin ultrasonic tips, micro/mini curettes). Finally, few data on adverse events or patient-reported outcomes are presently available. Some studies with short-term patient-reported outcomes were excluded from the review due to the inclusion criteria of 6-month follow-up. Additional limitations of the present review are evident. For PICOS question 1, as already discussed above, baseline

and final data within the same treatment arm were considered as independent. Furthermore, a limited number of studies was available for some sub-analysis, resulting in wide confidence and prediction intervals in the meta-analysis. The inclusion of split-mouth studies for the comparison of different instruments may also have introduced a certain risk of bias.

In conclusion and within the limitations of the present review, a comprehensive search and analysis of the available literature based on randomised controlled trials with a 6-month follow-up demonstrated that mechanical subgingival instrumentation is efficacious in the nonsurgical treatment of periodontitis, irrespective of type of instrument or mode of delivery.

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CONFLICT OF INTEREST

The authors declare no conflict of interest in regard to the present work. There were no external sources of funding to support conduct of this review.

CLINICAL RELEVANCE

Scientific rationale for the study: This systematic review provides an evidence summary of the efficacy of subgingival instrumentation, of sonic/ultrasonic/hand instruments and of different delivery timings in periodontitis treatment.

Principal findings: Weighted mean proportion of pocket closure was 74%. Nonsurgical mechanical subgingival instrumentation is efficacious in achieving infection control in periodontitis patients irrespective of whether performed by sonic/ultrasonic/hand instrument or delivered full mouth within 24 hours or in segments over multiple visits.

Practical implications: Clinicians should consider subgingival instrumentation as a key part of periodontal therapy and may choose instrument type and mode of delivery on an individual patient basis.

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Criteria	PICOS Question 1	PICOS Question 2	PICOS Question 3
Population	Adults ≥18 years with periodontitis		
Intervention	Subgingival instrumentation	Subgingival instrumentation performed with sonic/ultrasonic instruments	Subgingival instrumentation performed full mouth in a single visit
Comparison	Supra-gingival instrumentation/prophylaxis or no treatment	Subgingival instrumentation performed with hand instruments	Subgingival instrumentation performed quadrant or sextant wise over a series of visits
Outcomes	Clinical measures of periodontal status Patient reported outcomes		
Study	Randomised Controlled Trials		

Table 2. Search strategy for OVID Medline

1	exp Periodontitis/
2	(periodontiti* or pericementitid* or pericementiti* or gum* diseas* or gum* bleed* or periodont* diseas*).mp.
3	1 or 2
4	exp Dental Scaling/
5	(dent* scal* or root* scal* or subging* scal* or "sub gingiv* scal*" or supraging* scal* or supra ging* scal*).mp.
6	exp "Root Planing"/
7	root* plan*.mp.
8	exp Subgingival Curettage/
9	(subging* curettag* or root* debridement*).mp.
10	(curettag* adj4 (ging* or "sub ging*")).mp.
11	(debridement* adj4 (periodont* epithelial or root* surface* or full mouth or dent* quadrant)).mp.
12	exp Dental Prophylaxis/
13	(prophylaxis adj4 (dent* or teeth or tooth or oral)).mp.
14	exp Dental Deposits/
15	(deposit$1 adj4 (tooth or teeth or oral)).mp.
16	(dent* adj3 (plaque or calculus or tartar)).mp.
17	exp Dental Polishing/
18	(polish* adj4 (dent* or tooth or teeth)).mp.
19	(mechanic* adj3 debridement*).mp.
20	(instrument* adj3 (supra ging* or supraging* or "sub ging*" or subging* or full mouth)).mp.
21	*Dental Instruments/
22	(root* instrument* or manual instrument* or hand instrument* or handheld instrument* or power instrument*).mp.
23	(periodontit* therap* or "non surgic* periodontit* therap*").mp.
24	exp Dentistry/
25	dental.mp.
26	24 or 25
27	(sonic* or ultrasonic* or "ultra sonic*" or oscillat* or reciprocat* or rotat* or diamond* or perioplan* or rootsharp* or power driven or curette* or scaler*).mp.
28	26 and 27
29	OR/4-23
30	28 or 29
31	30 and 3
32	limit 31 to (clinical trial, all or clinical trial or randomized controlled trial)
33	(((single adj (blind* or masked)) or double) adj (blind* or masked)).ab. or (((single adj (blind* or masked)) or double) adj (blind* or masked)).ti.
34	(randomized or randomly or placebo or trial or (controlled adj study)).ab. or (randomized or randomly or placebo or trial or (controlled adj study)).ti.
35	(randomized controlled trial or controlled clinical trial).pt. or randomized.ab. or placebo.ab. or drug therapy.fs. or randomly.ab. or trial.ab. or groups.ab.
36	33 or 34 or 35
37	31 and 36
38	32 or 37
39	limit 38 to humans
40	limit 38 to animals
41	38 not 40
42	limit 41 to "all adult (19 plus years)"

Reason for exclusion	First author, year
Inclusion of antibacterial or antiseptic adjunctive therapy (n=29)	Aimetti 2011, Al-Mubarak 2000, Arpağ 2017, Babaloo 2018, Bollen 1996, Bollen 1998, Christgau 2006, Christgau 2007, Drisko 1998, Eren 2002, Farahmand 2016, Hellden 1979, Jones 1994, Kahl 2007, Knöfler 2007, Knöfler 2011, Konopka 2012, Maze 1995, Mongardini 1999, Polson 1996, Quirynen 1995, Roman-Torres 2018, Rotundo 2010, Rupf 2005, Santuchi 2015, Santuchi 2016, Silveira 2017, Vandekerckhove 1996, Walsh 1986
No relevant data reported (n=28)	Alves 2004, Alves 2005, Apatzidou 2004b, Apatzidou 2004c, Åslund 2008, Braun 2003, Chung 2011, Copulos 1993, Dahiya 2013, Del Peloso Ribeiro 2007, Forabosco 2006, Friesen 2002, Gomes 2014, Kaldahl 1988, Kamma 2009, Kocher 2005, Koshy 2001, Lopes 2010, Pawlowski 2005, Sato 1993, Sculean 2004, Southard 1989, Türktekin 2018, Tomasi 2006, Tomasi 2007, Ueda 2014, Verrusio 2018, Zee 2006
Not randomised (n=7)	Chapper 2005, D'Ercole 2006, Dragoo 1992, Jenkins 2000, Kocher 2001, Lim 1996, Quirynen 2000
Non-English language (n=1)	Nonhoff 2006
Review article (n=1)	Greenstein 2004

Study Characteristic	Number of Studies (N=19)	First Author, Year
Region		
Europe	13	Laurell & Pettersson 1988, Apatzidou & Kinane 2004, Obeid et al. 2004, Wennström et al. 2005, Jervøe-Storm et al. 2006, Quirynen et al. 2006, Swierkot et al. 2009, Ioannou et al. 2009, Loggner Graf et al. 2009, Zijnge et al. 2010, Malali et al. 2012, Predin et al. 2014, Petelin et al. 2015
South America	4	Zanatta et al. 2006, Del Peloso Ribeiro et al. 2008, Meulman et al. 2013, Fonseca et al. 2015
Australasia	2	Koshy et al. 2005, Kapellas et al. 2013
Setting		
Private	1	Zijnge et al. 2010
Private & University	1	Wennström et al. 2005
University	16	Laurell & Pettersson 1988, Apatzidou & Kinane 2004, Obeid et al. 2004, Koshy et al. 2005, Jervøe-Storm et al. 2006, Quirynen et al. 2006, Zanatta et al. 2006, Del Peloso Ribeiro et al. 2008, Swierkot et al. 2009, Ioannou et al. 2009, Loggner Graf et al. 2009, Malali et al. 2012, Meulman et al. 2013, Predin et al. 2014, Fonseca et al. 2015, Petelin et al. 2015
Public	1	Kapellas et al. 2013
Year of Publication		
1988-2000	1	Laurell & Pettersson 1988
2001-2010	12	Apatzidou & Kinane 2004, Obeid et al. 2004, Wennström et al. 2005, Koshy et al. 2005, Jervøe-Storm et al. 2006, Quirynen et al. 2006, Zanatta et al. 2006, Del Peloso Ribeiro et al. 2008, Swierkot et al. 2009, Ioannou et al. 2009, Loggner Graf et al. 2009, Zijnge et al. 2010
2011-Present	6	Malali et al. 2012, Meulman et al. 2013, Kapellas et al. 2013, Predin et al. 2014, Fonseca et al. 2015, Petelin et al. 2015

Table 5. Evidence Table of PICOS Characteristics of Included Studies.

Author, year, country, title	Population of study	Treatment Groups	Treatment Outcomes	Study Findings
Laurell & Pettersson, (1988) Sweden Periodontal healing after treatment with either the Titan-S sonic scaler or hand instruments	**Setting:** University (single center) **N** = 12 **Age:** 36 - 55 years **Gender:** Female n=7 Male n=5 **Smoking status:** Not specified **Periodontal disease status**: Moderate	**RCT Design:** Split mouth **Test:** Subgingival debridement (completed within 1 week) with sonic scaler **Control:** SRP (completed within 1 week) with hand instruments No retreatment. **Teeth included:** Single and multi-rooted	**PICOS:** 1 and 2 **Values reported:** Full-mouth BOP reduction Pocket closure (PPD <4 mm) Full-mouth plaque score **Reported for:** All sites ≥4mm **Other Outcomes:** Not reported **Timepoints:** 3 months	**Pico 1**: clinical benefit of subgingival instrumentation **Pico 2**: no difference between hand and ultrasonic instruments **Pico 3:** n/a
Apatzidou & Kinane, (2004) Scotland Quadrant root planing versus same-day full-mouth root planing. I. Clinical findings	**Setting:** University (single center) **N** = 40 **Age:** 31 - 70 years **Gender:** Female n=17 Male n=23 **Smoking status:** n=15 smokers **Periodontal disease status**: Moderate to severe	**RCT Design:** Parallel **Test:** FM-SRP performed on the same day with a combination of hand and ultrasonic instruments **Control:** Q-SRP one hour per quadrant with hand and ultrasonic instruments **Teeth included:** Single and multi-rooted At 13 weeks, retreatment of sites with PD ≥5 mm & BOP.	**PICOS:** 1 and 3 **Values reported:** Mean PPD reduction Mean CAL gain Full-mouth BOP reduction Pocket closure (PPD <5 mm) Full-mouth plaque score **Reported for:** All sites ≥5 mm **Other Outcomes:** VAS scale of patient comfort **Timepoints:** 6 months	**Pico 1**: clinical benefit of subgingival instrumentation **Pico 2:** n/a **Pico 3**: no difference between full mouth and quadrant approach
Obeid *et al.* (2004) Belgium Comparative clinical responses related to the use of various periodontal instrumentation	**Setting:** University (single center) **N** = 20 **Age:** 40 - 69 years **Gender:** Female n=10 Male n=10 **Smoking status:** n=4 smokers	**RCT Design:** Split mouth **Test:** UD (2 minutes/tooth) ultrasonic **Control:** SRP (3 minutes/tooth) hand instruments **Teeth included:** Single and multi-rooted	**PICOS:** 1 and 2 **Values reported:** Mean PPD reduction Mean CAL gain Full-mouth BOP reduction Pocket closure (PPD δ5 mm) **Reported for:** All sites	**Pico 1**: clinical benefit of subgingival instrumentation **Pico 2**: no difference between hand and ultrasonic instruments **Pico 3**: n/a

	Periodontal disease status: Moderate to severe chronic periodontitis, 2 molars and 3 sites single rooted PPD ≥4 mm in each quadrant	4 treatment groups (only 2 considered). 6 months duration. Recall at 1 month for OHI.	Shallow sites 3-5 mm Deep sites ≥6 mm **Other Outcomes:** Not reported **Timepoints:** 3 and 6 months	
Author, year, country, title	**Population of study**	**Treatment Groups**	**Treatment Outcomes**	**Study Findings**
Koshy *et al.* (2005) Japan Effects of single-visit full-mouth ultrasonic debridement versus quadrant-wise ultrasonic debridement	**Setting:** University (single center) **N** = 24 **Age:** 34 - 66 years **Gender:** Female n=15 Male n=9 **Smoking status:** non-smokers **Periodontal disease status**: Moderate to severe	**RCT Design:** Parallel **Test:** FMS (1 appointment) ultrasonic **Control:** Q-SRP (no time limit) ultrasonic **Teeth included:** Single and multi-rooted 3 treatment groups (only 2 considered), All subjects were recalled every month for re-inforcement of oral hygiene instructions and professional tooth cleaning with a rubber cup and polishing paste.	**PICOS:** 1 and 3 **Values reported:** Mean PPD reduction Mean CAL gain Full-mouth BOP reduction Pocket closure (PPD <5mm) Full-mouth plaque score **Reported for:** All sites ≥5mm Shallow sites 5-6 mm Deep sites ≥7 mm **Other Outcomes:** VAS scale of patient comfort Number of adverse events **Timepoints:** 6 months	**Pico 1**: clinical benefit of subgingival instrumentation **Pico 2**: n/a **Pico 3**: no difference between full mouth and quadrant approach
Wennström *et al.* (2005) Sweden & Italy Full mouth ultrasonic debridement versus quadrant scaling and root planing as an initial approach in the treatment of chronic periodontitis	**Setting:** University (Sweden) & private practice (Italy) **N** = 41 **Age:** 25 - 75 years **Gender:** Female n=19 Male n=22 **Smoking status:** n=20 smokers **Periodontal disease status**: Moderate to severe	**RCT Design:** Parallel **Test:** Full mouth debridement with 1 hour time limit with ultrasonic instrument **Control:** Quadrant SRP without time limit with hand instruments **Teeth included:** Single and multi-rooted At 3 months, retreatment of sites with PPD ≥5 mm.	**PICOS:** 1, 2, and 3 **Values reported:** Mean PPD reduction Mean CAL gain Full-mouth BOP reduction Pocket closure (PPD δ4 mm) Full-mouth plaque score **Reported for:** All sites ≥5 mm Shallow sites 5-6 mm Deep sites ≥7 mm **Other Outcomes:** VAS scale of patient comfort Root sensitivity ≥5 days post-treatment Number of adverse events **Timepoints:** 3 and 6 months	**Pico 1**: clinical benefit of subgingival instrumentation **Pico 2**: no difference between hand and ultrasonic instruments **Pico 3**: no difference between full mouth and quadrant approach

Author, year, country, title	**Population of study**	**Treatment Groups**	**Treatment Outcomes**	**Study Findings**
Jervøe-Storm *et al.* (2006) Germany Clinical outcomes of quadrant root planing versus full-mouth root planing	**Setting:** University (single center) **N** = 20 **Age:** 53 years **Gender:** Female n=9 Male n=11 **Smoking status:** n=2 smokers **Periodontal disease status**: Chronic periodontitis defined as ≥2 teeth per quadrant with PPD ≥5 mm with presence of BOP	**RCT Design:** Parallel **Test:** FMRP (2 sessions within 24h) with combination hand and ultrasonic instruments for about 1 hour per quadrant **Control:** QRP, combination hand and ultrasonic instruments, approximately 1 hour per quadrant **Teeth included:** Single and multi-rooted No retreatment	**PICOS: 1** and 3 **Values reported:** Mean reduction PPD Mean reduction CAL Full-mouth BOP reduction Relative change BoP Pocket closure (PPD δ4 mm) Site with CAL gain ε2 mm. **Reported for:** All sites $\geq$5 mm Shallow sites 5-6 mm Deep sites $\geq$7 mm **Other Outcomes:** Not reported **Timepoints:** 3 and 6 months	**Pico 1**: clinical benefit of subgingival instrumentation **Pico 2**: n/a **Pico 3**: no difference between full mouth and quadrant approach

Quirynen *et al.* (2006) Belgium Benefit of "one-stage full-mouth disinfection" is explained by disinfection and root planing within 24 hours: a randomized controlled trial	**Setting:** University (single center) **N** = 29 **Age:** 31- 75 years **Gender:** Female n=15 Male n=14 **Smoking status:** n=8 smokers **Periodontal disease status**: Moderate	**RCT Design:** Parallel **Test:** FM-SRP (2 sessions within 24h) with hand instruments **Control:** Q-SRP (no time limit) with hand instruments **Teeth included:** Single and multi-rooted 5 treatment groups (only 2 considered) No retreatment	**PICOS:** 1 and 3 **Values reported:** Mean reduction PPD Mean reduction CAL BOP reduction Plaque surface extension **Reported for:** All sites ≥4 mm Shallow sites 4-5.5 mm Deep sites ≥6 mm **Other Outcomes:** Staining index **Timepoints:** 8 months	**Pico 1**: clinical benefit of subgingival instrumentation **Pico 2**: n/a **Pico 3**: no difference between full mouth and quadrant approach
Zanatta *et al.* (2006) Brazil Periodontal debridement with povidone-iodine in periodontal treatment: short-term clinical and biochemical observations	**Setting:** University (single center) **N** = 25 **Age:** 27 - 62 years **Gender:** not specified **Smoking status:** not specified **Periodontal disease status**: Moderate	**RCT Design:** Parallel **Test:** FMS (45 minutes) ultrasonic **Control:** Q-SRP (no time limit) hand instruments **Teeth included:** Single and multi-rooted 3 treatment groups (only 2 considered) Oral hygiene reinforcement and supragingival polishing twice-weekly during study period	**PICOS:** 1 and 3 **Values reported:** Mean reduction PPD Mean reduction CAL Full-mouth bleeding score **Reported for:** All sites ≥5 mm Shallow sites 5-6 mm Deep sites ≥7 mm **Other Outcomes:** Not reported **Timepoints:** 3 months	**Pico 1**: clinical benefit of subgingival instrumentation **Pico 2**: n/a **Pico 3**: no difference between full mouth and quadrant approach
Author, year, country, title	**Population of study**	**Treatment Groups**	**Treatment Outcomes**	**Study Findings**
Del Peloso Ribeiro *et al.* (2008) Brazil Periodontal debridement as a therapeutic approach for severe chronic periodontitis: a clinical, microbiological and immunological study	**Setting:** University (single center) **N** = 25 **Age:** 30 - 66 years **Gender:** Female n=18 Male n=7 **Smoking status:** non-smokers **Periodontal disease status**: Severe	**RCT Design:** Parallel **Test:** FMS (45 minutes) ultra **Control:** Q-SRP (no time limit) combination **Teeth included:** Single and multi-rooted At 3 months, retreatment of sites with PPD ≥5 mm and BOP.	**PICOS:** 1 and 3 **Values reported:** Mean PPD reduction Mean CAL gain Full-mouth BOP reduction Pocket closure (PPD ≤5 mm and no BoP) Full-mouth plaque score **Reported for:** All sites ≥5 mm Shallow sites 5-6 mm Deep sites ≥7 mm	**Pico 1**: clinical benefit of subgingival instrumentation **Pico 2**: n/a **Pico 3**: no difference between full mouth and quadrant approach

			Other Outcomes: VAS scale of patient comfort Body temperature Number of analgesics taken Number of adverse events **Timepoints:** 3 and 6 months	
Ioannou *et al.* (2009) Greece Hand instrumentation versus ultrasonic debridement in the treatment of chronic periodontitis: a randomized clinical and microbiological trial	**Setting:** University (single center) **N** = 33 **Age:** 33 – 68 years **Gender:** Female n=20 Male n=13 **Smoking status:** 51% smokers **Periodontal disease status**: Advanced chronic periodontitis: ≥4 sites with PPD ≥5 mm and BOP in at least two quadrants. Furcation excluded.	**RCT Design:** Parallel **Test:** Q-UD (3-4 sessions, no time restriction) ultra **Control:** Q-SRP (3-4 sessions, no time restriction) control **Teeth included:** Single and multi-rooted No retreatment.	**PICOS:** 1 and 2 **Values reported:** Mean reduction PPD Mean reduction CAL Full-mouth plaque score **Reported for:** All sites Shallow sites 4-6 mm Deep sites >6 mm **Other Outcomes:** Not reported **Timepoints:** 3 and 6 months	**Pico 1**: clinical benefit of subgingival instrumentation **Pico 2**: no difference between hand instruments and ultrasonic according to authors **Pico 3**: n/a
Author, year, country, title	**Population of study**	**Treatment Groups**	**Treatment Outcomes**	**Study Findings**

Loggner Graf *et al.* (2009) Sweden Full-mouth versus quadrant-wise scaling--clinical outcome, efficiency and treatment discomfort	**Setting:** University (single center) **N** = 18 **Age:** 28 – 65 years **Gender:** Female n=15 Male n=3 **Smoking status:** n=9 smokers **Periodontal disease status**: Advanced chronic periodontitis	**RCT Design:** Parallel **Test:** FM-SRP (2 sessions within 24h) combination ultrasonic and hand instruments **Control:** Q-SRP (no time limit) combination ultrasonic and hand instruments **Teeth included:** Single and multi-rooted Re-scaling and oral hygiene instructions at 3 months.	**PICOS:** 1 and 3 **Values reported:** Mean reduction PPD Full-mouth BOP reduction Full-mouth plaque score **Reported for:** All sites **Other Outcomes:** VAS scale of patient comfort **Timepoints:** 6 months	**Pico 1**: clinical benefit of subgingival instrumentation **Pico 2**: n/a **Pico 3**: no difference between full mouth and quadrant approach
Swierkot *et al.* (2009) Germany One-stage full-mouth disinfection versus quadrant and full-mouth root planing	**Setting:** University (single center) **N** = 16 **Age:** 28 – 63 years **Gender:** Female n=13 Male n=3 **Smoking status:** n=4 smokers **Periodontal disease status**: Generalized chronic periodontitis, at least 6 sites with PPD ≥5 mm and BOP	**RCT Design:** Parallel **Test:** FMS (2 sessions within 24h) combination ultrasonic and hand instruments **Control:** Q-SRP (no time limit) combination ultrasonic and hand instruments **Teeth included:** Single and multi-rooted 3 treatment groups (only 2 considered) No retreatment.	**PICOS:** 1 and 3 **Values reported:** Mean reduction PPD Mean reduction CAL Full-mouth BOP reduction Full-mouth plaque score **Reported for:** All sites Shallow sites 4-6 mm Deep sites ≥7mm **Other Outcomes:** Number of adverse events **Timepoints:** 4 and 8 months	**Pico 1**: clinical benefit of subgingival instrumentation **Pico 2**: n/a **Pico 3**: no difference between full mouth and quadrant approach
Zijnge *et al.* (2010) Netherlands The recolonization hypothesis in a full-mouth or multiple-session treatment protocol: a blinded, randomized clinical trial	**Setting:** Private dental practice (single center) **N** = 38 **Age:** 25 – 75 years **Gender:** Female n=16 Male n=22 **Smoking status:** n=0 smokers **Periodontal disease status**: Chronic periodontitis, >10% sites with PPD ≥6 mm	**RCT Design:** Parallel **Test:** FM-SRP (3 hours) hand instruments **Control:** Q-SRP (1 hour per quadrant) hand instruments **Teeth included:** Single and multi-rooted No retreatment.	**PICOS:** 1 and 3 **Values reported:** Mean reduction PPD Full-mouth BOP reduction Pocket closure (PPD <3 mm when initial PPD was ≥5 mm) Full-mouth plaque score **Reported for:** All sites ≥4 mm Shallow sites 4-6 mm Deep sites ≥7 mm **Other Outcomes:** Number of adverse events **Timepoints:** 3 months	**Pico 1**: clinical benefit of subgingival instrumentation **Pico 2**: n/a **Pico 3**: no difference between full mouth and quadrant approach

Author, year, country, title	Population of study	Treatment Groups	Treatment Outcomes	Study Findings
Malali *et al.* (2012) Turkey Er:YAG lasers versus ultrasonic and hand instruments in periodontal therapy: clinical parameters, intracrevicular micro-organism and leukocyte counts	**Setting:** University (single center) **N** = 20 **Age:** Not specified **Gender:** Not specified **Smoking status:** n=0 smokers **Periodontal disease status**: Chronic periodontitis, ≥2 sites with PPD 4-6 mm and ≥2 sites with PPD ≥7 mm with BOP and mobility 0-2	**RCT Design:** Parallel **Test:** UD (4 to 6 sessions) ultrasonic instruments only **Control:** SRP (4 to 6 sessions) hand instruments only **Teeth included:** Single and multi-rooted 3 treatment groups (only 2 considered). No retreatment.	**PICOS:** 1 and 2 **Values reported:** Mean reduction PPD Mean reduction CAL Full-mouth BOP reduction Full-mouth plaque score **Reported for:** All sites Shallow sites 4-6 mm Deep sites ≥7 mm **Other Outcomes:** Not reported **Timepoints:** 3 months	**Pico 1**: clinical benefit of subgingival instrumentation **Pico 2**: no difference between hand and ultrasonic instruments **Pico 3**: n/a
Kapellas *et al.* (2013) Australia Effects of full-mouth scaling on the periodontal health of Indigenous Australians: a randomized controlled trial	**Setting:** Public dental clinics (multiple clinical centers) **N** = 169 **Age:** Mean age of 40 **Gender:** Female n=62 Male n=107 **Smoking status:** n=87 smokers **Periodontal disease status**: Chronic Periodontitis, ≥2 proximal sites with CAL ≥4 mm or with PPD ≥5 mm	**RCT Design:** Parallel **Test:** SRP (1 session, no time limit) hand and ultra **Control:** no treatment **Teeth included:** Single and multi-rooted No retreatment.	**PICOS:** 1 **Values reported:** Pocket closure (PPD <4 mm) Full-mouth plaque score **Reported for:** All sites ≥4 mm **Other Outcomes:** Number of adverse events **Timepoints:** 3 months	**Pico 1**: clinical benefit of subgingival instrumentation **Pico 2**: n/a **Pico 3**: n/a
Meulman *et al.* (2013) Brazil One stage, full-mouth, ultrasonic debridement in the treatment of severe chronic periodontitis in smokers: a preliminary, blind and randomized clinical trial	**Setting:** University (single center) **N** = 20 **Age:** Mean age of 43 years **Gender:** Female n=9 Male n=11 **Smoking status:** n=20 smokers (≥5 pack years) **Periodontal disease status**: Severe chronic periodontitis, ≥9 teeth with PPD ≥5 mm and BOP	**RCT Design:** Parallel **Test:** FMUD (1 session 45 minutes) ultrasonic instruments only **Control:** Q-SRP (1 week interval) hand instruments only **Teeth included:** Single and multi-rooted 3 treatment groups (only 2 considered) Monthly recall for SPT.	**PICOS:** 1 and 3 **Values reported:** Mean reduction PPD Mean reduction CAL Full-mouth BOP reduction Pocket closure (PPD <5 mm and no BoP) Full-mouth plaque score **Reported for:** All sites **Other Outcomes:** Not reported	**Pico 1**: clinical benefit of subgingival instrumentation **Pico 2**: n/a **Pico 3**: no difference between full mouth and quadrant approach

			Timepoints: 3 and 6 months	
Author, year, country, title	**Population of study**	**Treatment Groups**	**Treatment Outcomes**	**Study Findings**
Predin *et al.* (2014) Serbia Clinical and microbiological effects of quadrant versus full-mouth root planing - A randomized study	**Setting:** University (single center) **N** = 40 **Age:** 32 – 75 years **Gender:** Female n=31 Male n=9 **Smoking status:** n=7 smokers **Periodontal disease status**: Chronic Periodontitis, ≥2 teeth/quadrant with PPD ≥5 mm and BOP	**RCT Design:** Parallel **Test:** FM-SRP (2 sessions within 24h) combination hand and ultrasonic instruments **Control:** SRP (4 sessions) combination hand and ultrasonic instruments **Teeth included:** Single and multi-rooted No retreatment	**PICOS:** 1 and 3 **Values reported:** Mean reduction PPD Mean reduction CAL Pocket closure (PPDδ4mm) Full-mouth plaque score **Reported for:** All sites All sites ≥4 mm Shallow sites 5-6 mm Deep sites ≥7 mm **Other Outcomes:** Number of adverse events **Timepoints:** 3 months	**Pico 1**: clinical benefit of subgingival instrumentation **Pico 2**: n/a **Pico 3**: no difference between full mouth and quadrant approach

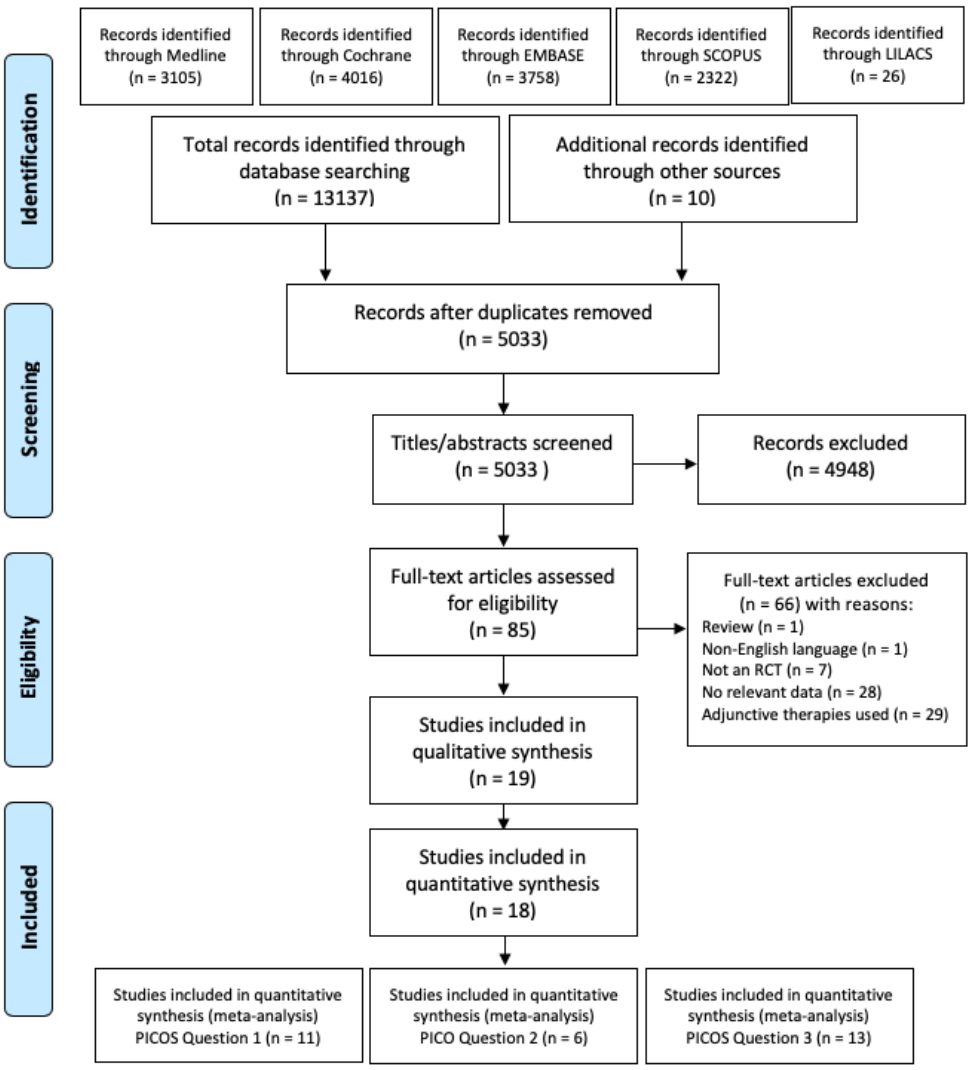
Fonseca *et al.* (2015) Brazil Clinical and microbiologic evaluation of scaling and root planing per quadrant and one-stage full-mouth disinfection associated with azithromycin or chlorhexidine: a clinical randomized controlled trial	**Setting:** University (2 clinical centers) **N** = 28 **Age:** Not specified **Gender:** Not specified **Smoking status:** Not specified **Periodontal disease status**: Mild/moderate	**RCT Design:** Parallel **Test:** FM-SRP (2x1 hour within 24 hours) hand instruments **Control:** Q-SRP (30 minutes per quadrant) hand instruments **Teeth included:** Single and multi-rooted 6 treatment groups (only 2 considered) No retreatment	**PICOS:** 1 and 3 **Values reported:** Mean reduction PPD Mean reduction CAL Pocket closure (PD <4 mm when CAL ε3 mm) Full-mouth plaque score **Reported for:** All sites Shallow sites 4-5 mm Deep sites ≥6 mm **Other Outcomes:** Not reported **Timepoints:** 3 and 6 months	**Pico 1**: clinical benefit of subgingival instrumentation **Pico 2**: n/a **Pico 3**: no difference between full mouth and quadrant approach
Author, year, country, title	**Population of study**	**Treatment Groups**	**Treatment Outcomes**	**Study Findings**
Petelin *et al.* (2015) Slovenia Effect of repeated adjunctive antimicrobial photodynamic therapy on subgingival periodontal pathogens in the treatment of chronic periodontitis	**Setting:** University (single center) **N** = 18 **Age:** 37 – 64 years **Gender:** Female n=10 Male n=8 **Smoking status:** n=0 smokers **Periodontal disease status**: At least 4 teeth with PPD ≥4 mm in every quadrant	**RCT Design:** Parallel **Test:** UD ultra **Control:** SRP hand **Teeth included:** Single and multi-rooted 3 treatment groups (only 2 considered) Retreatment every 3 months	**PICOS:** 1 and 2 **Values reported:** Mean reduction PPD Mean reduction CAL Full-mouth BOP reduction Pocket closure (PPD δ4 mm) **Reported for:** All sites Shallow sites 4-5 mm Deep sites >6 mm **Other Outcomes:** Not recorded **Timepoints:** 3, 6 and 12 months	**Pico 1**: clinical benefit of subgingival instrumentation **Pico 2**: no difference between hand and ultrasonic instruments **Pico 3**: n/a

SRP: Scaling and root planning; PPD: Probing pocket depth; RCT: Randomised controlled trial; CAL: Clinical attachment level; FMRP: Full mouth root planing; FM-SRP: Full mouth scaling and root planing; Q-SRP: Quadrant scaling and root planing; QRP: Quadrant root planing; VAS: Visual analogue scale; Q-UD: Quadrant ultrasonic debridement; UD: Ultrasonic debridement; FMUD: Full mouth ultrasonic debridement; BOP: bleeding on probing.

Table 6. Overview on meta-analyses performed.

		All sites			**Shallow sites**			**Deep sites**		
		PICOS Q1	PICOS Q2	PICOS Q3	PICOS Q1	PICOS Q2	PICOS Q3	PICOS Q1	PICOS Q2	PICOS Q3
3/4 months	PD red	9 studies *Appendix F1*	4 studies *Appendix F4*	6 studies *Appendix F7*	10 studies *Appendix F2*	3 studies *Appendix F5*	7 studies *Appendix F8*	11 studies *Appendix F3*	3 studies *Appendix F6*	8 studies *Appendix F10*
	CAL gain		4 studies *Appendix F4*	4 studies *Appendix F7*			4 studies *Appendix F8*			5 studies *Appendix F10*
	Pocket closure	5 studies *Appendix F1*		4 studies *Appendix F7*						
6/8 months	PD red	11 studies *Figure 3a*	4 studies *Figure 4*	8 studies *Figure 5*	6 studies *Figure 3b*	3 studies *Appendix F5*	4 studies *Appendix F9*	7 studies *Figure 3b*	3 studies *Appendix F6*	5 studies *Appendix F11*
	CAL gain		4 studies *Figure 4*	6 studies *Figure 5*			3 studies *Appendix F9*			4 studies *Appendix F11*
	Pocket closure	5 studies *Figure 3a*		5 studies *Figure 5*						

No meta-analysis | Meta-analysis - significant risk for bias | Meta-analysis - no significant risk for bias



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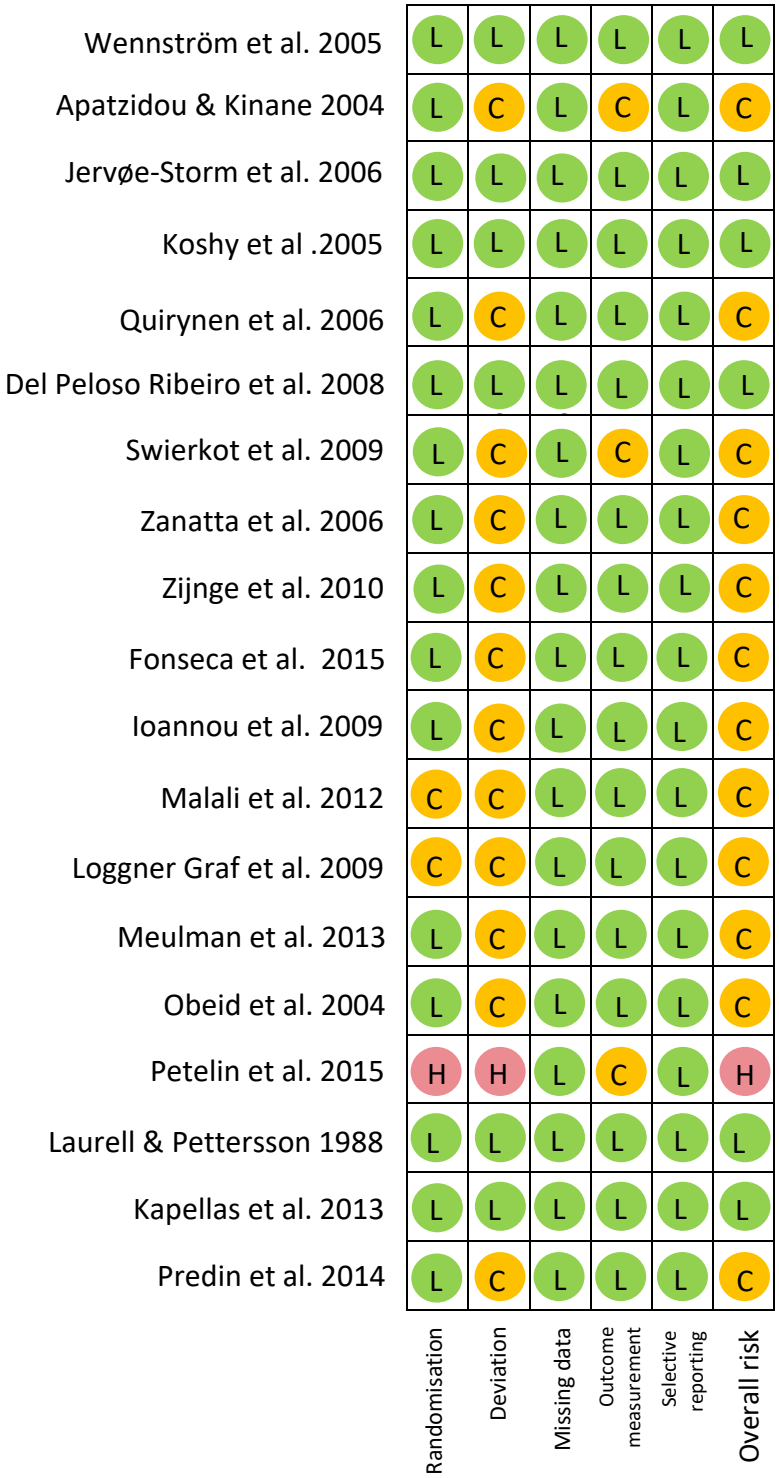

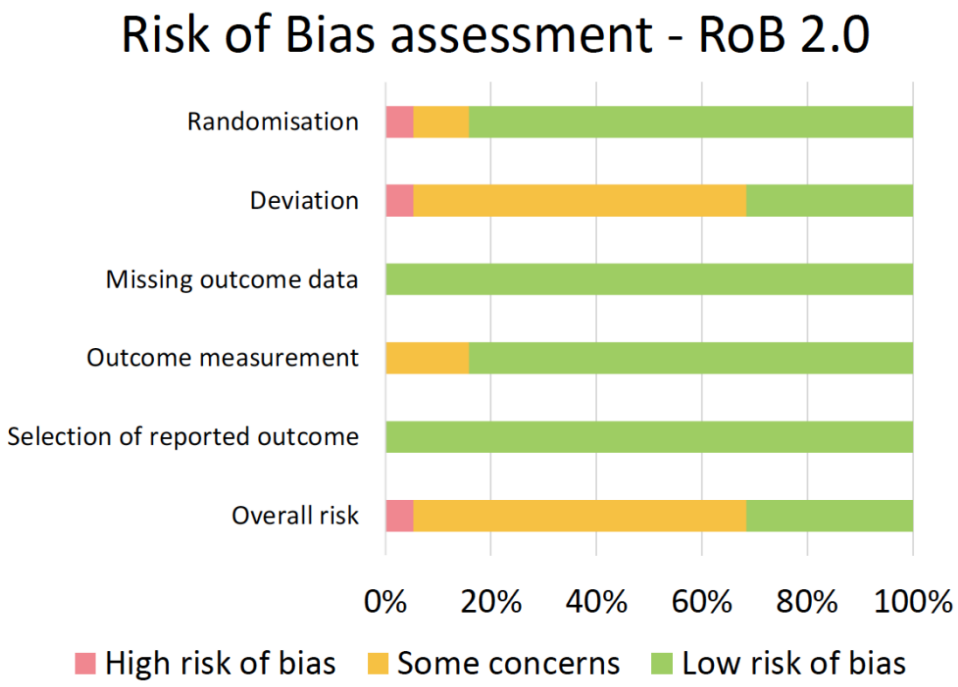

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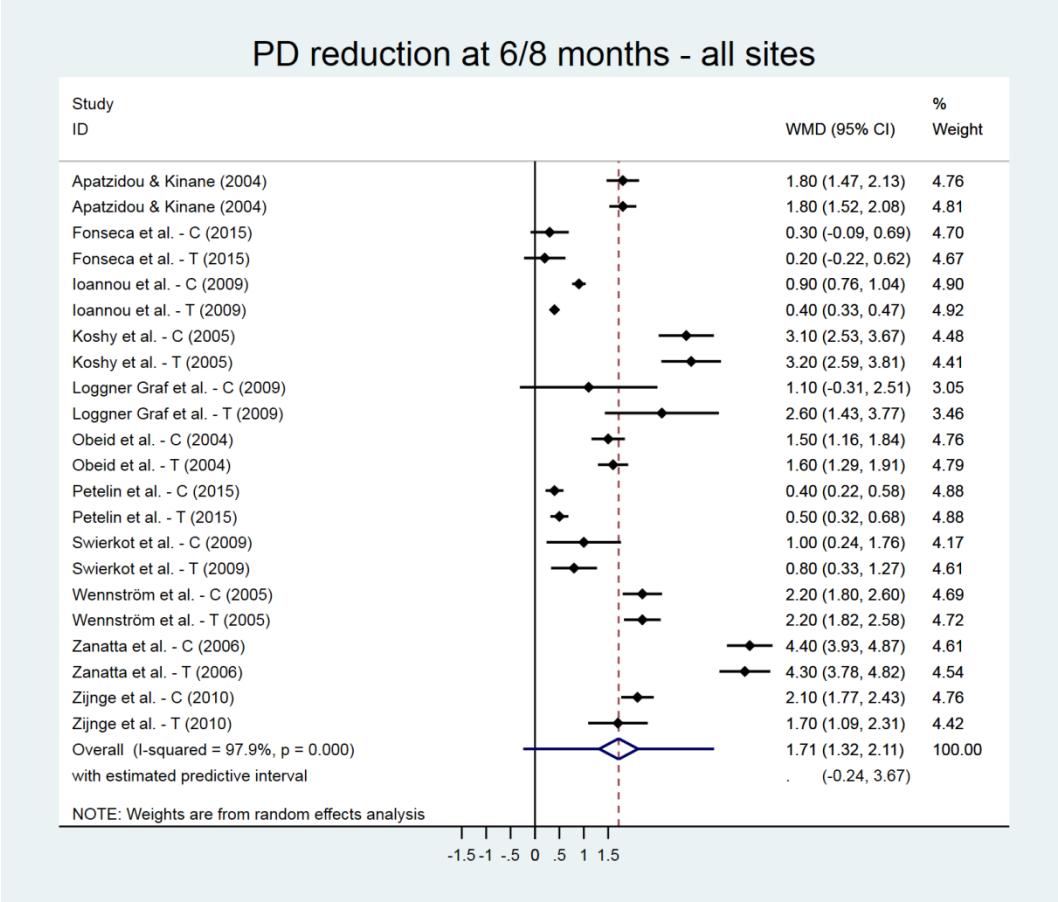

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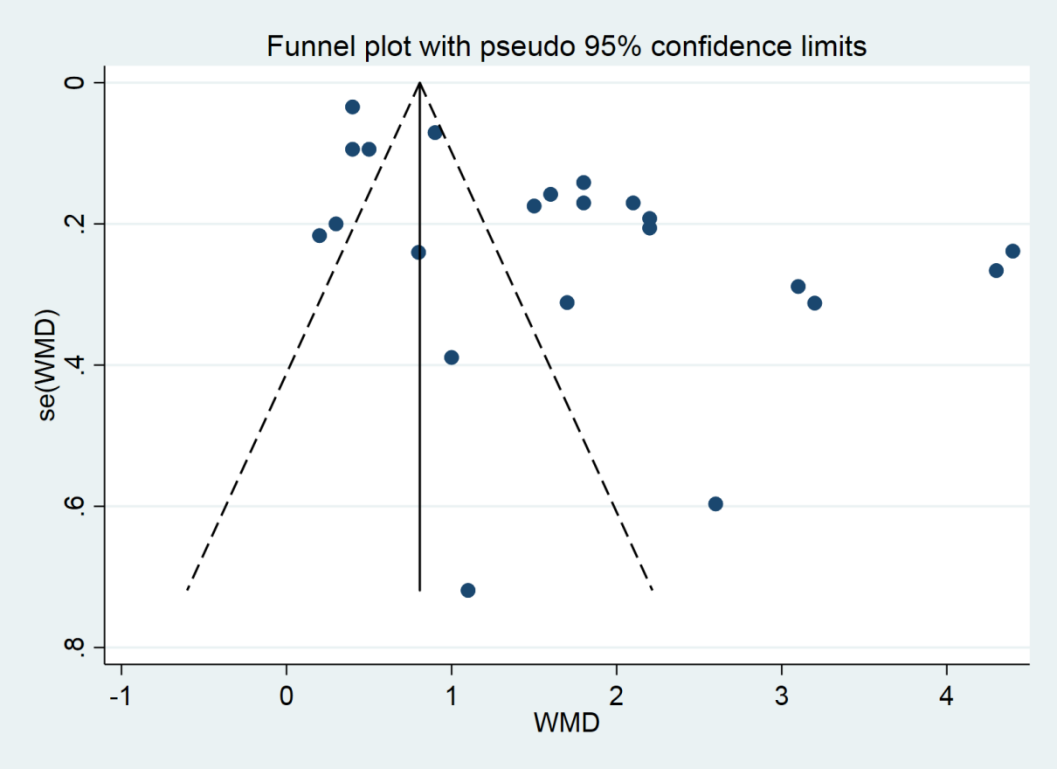

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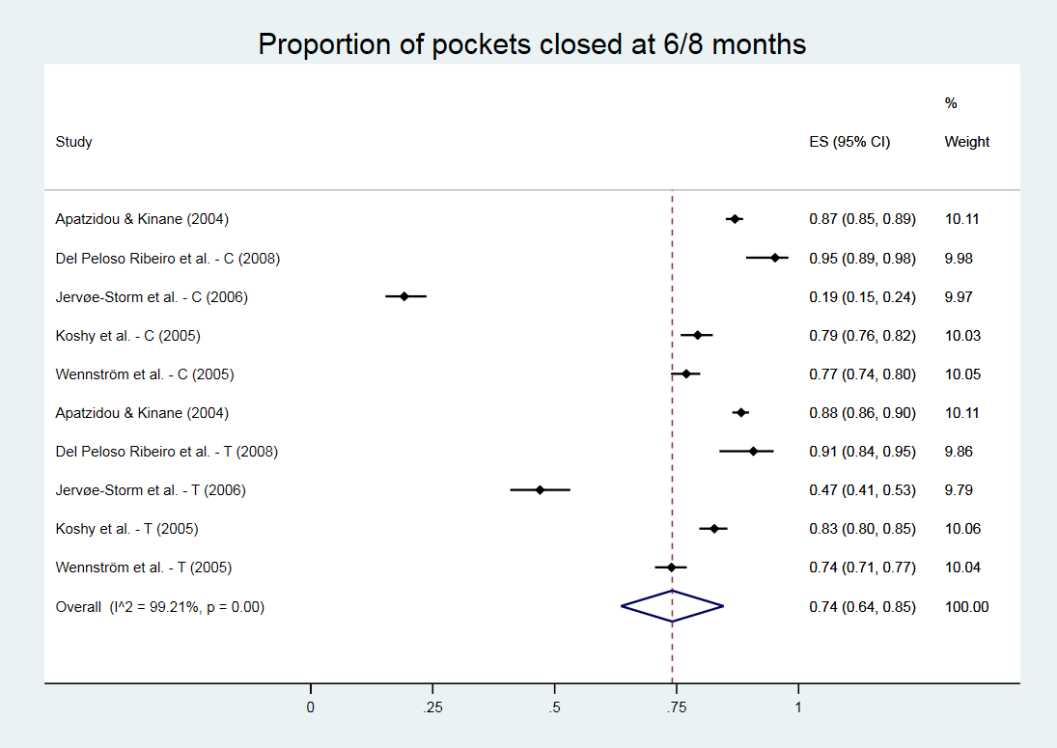

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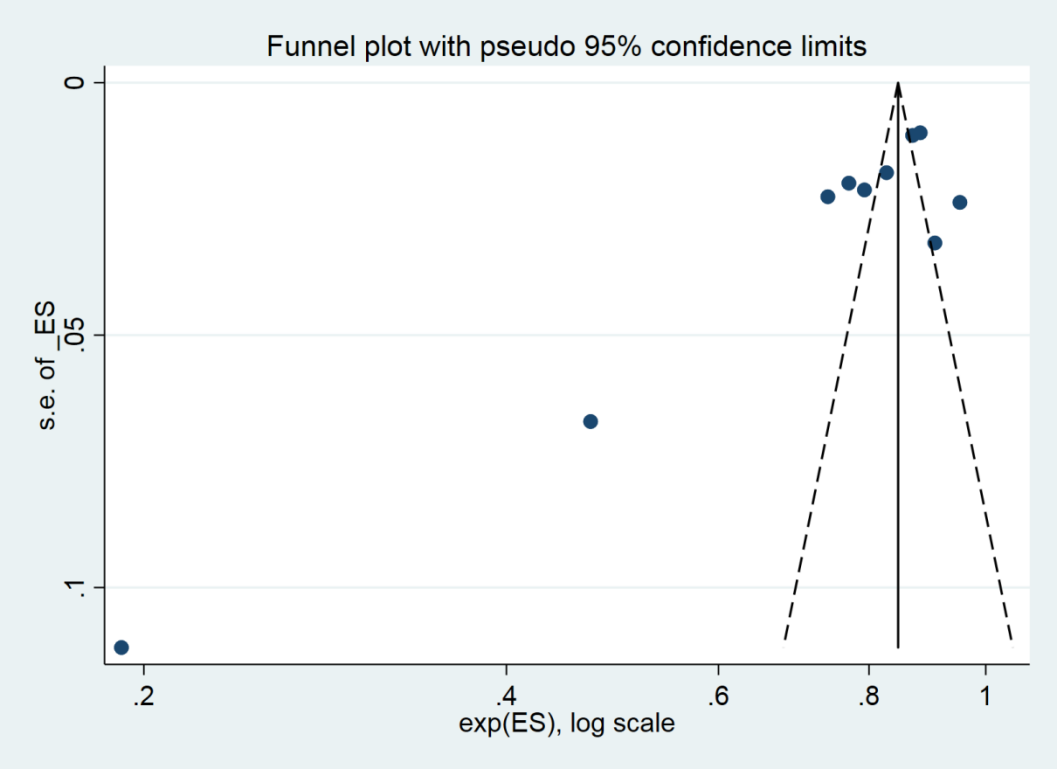

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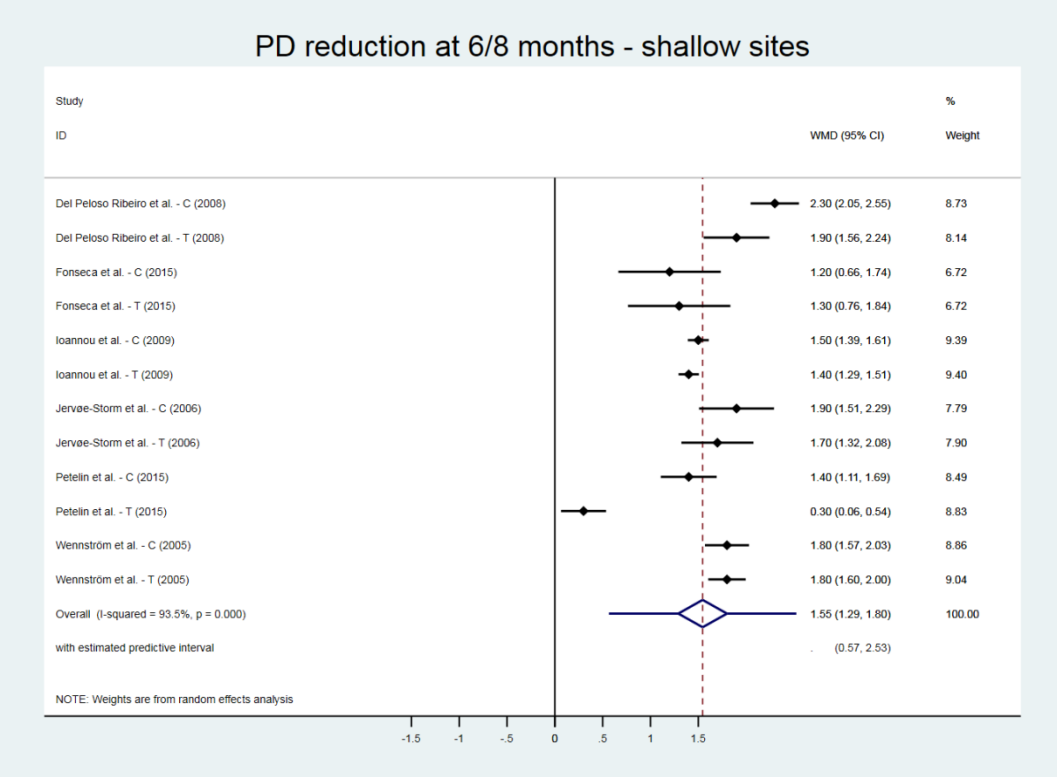

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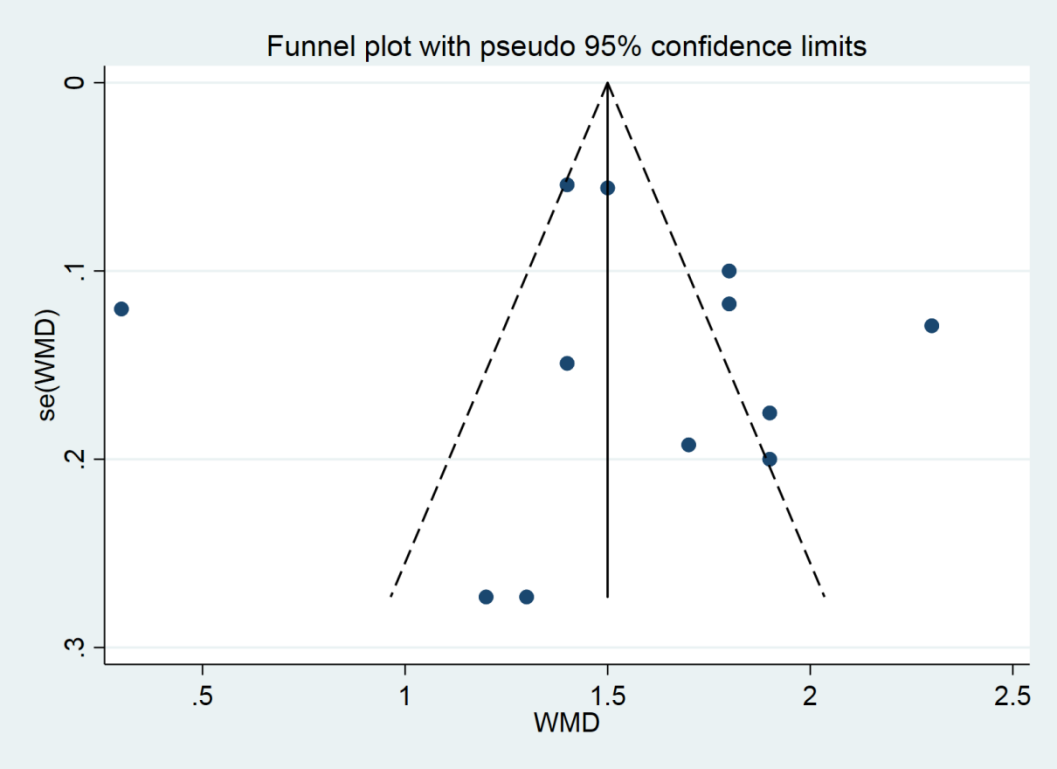

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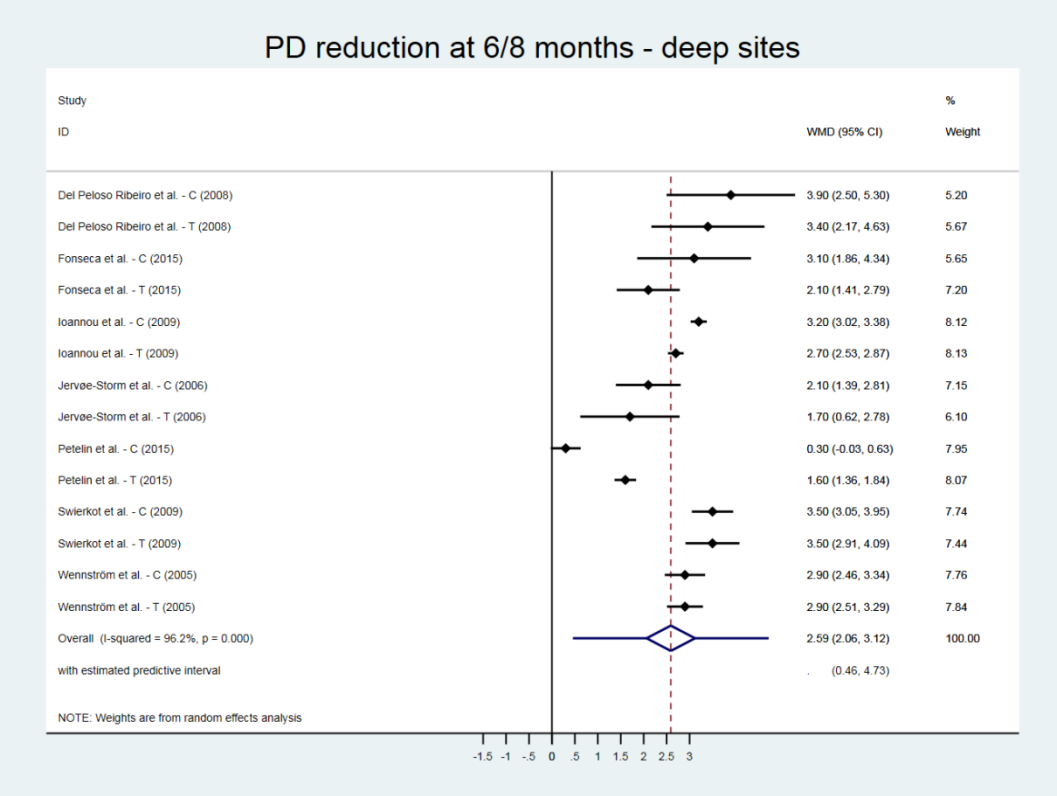

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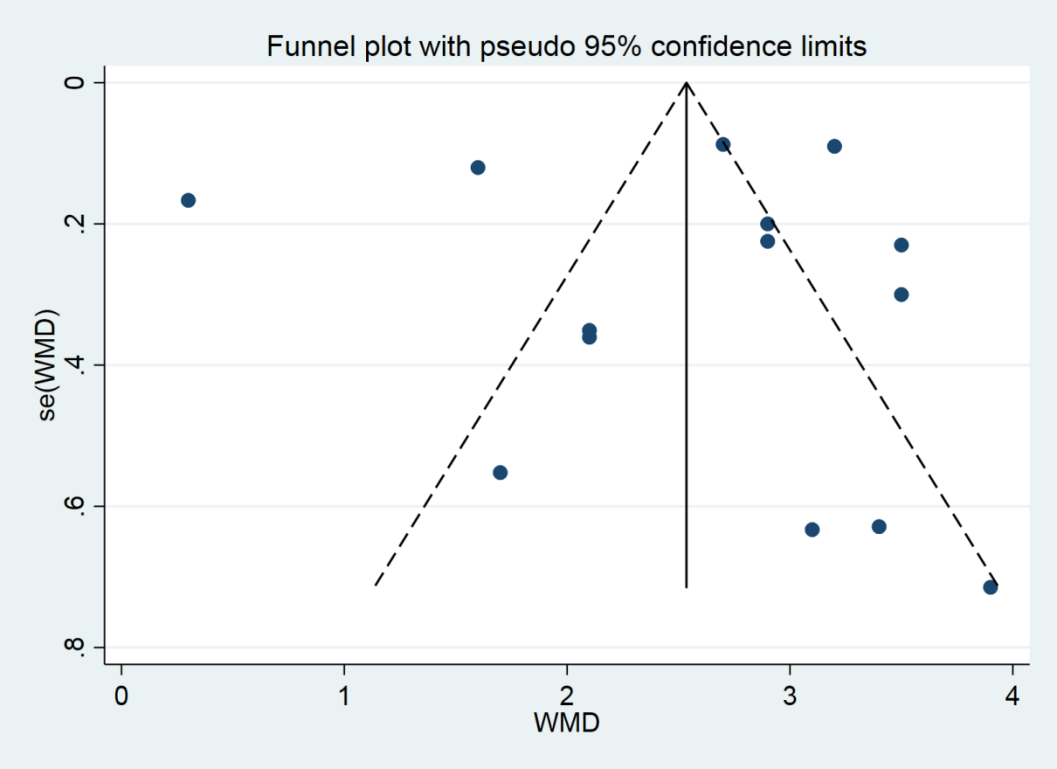

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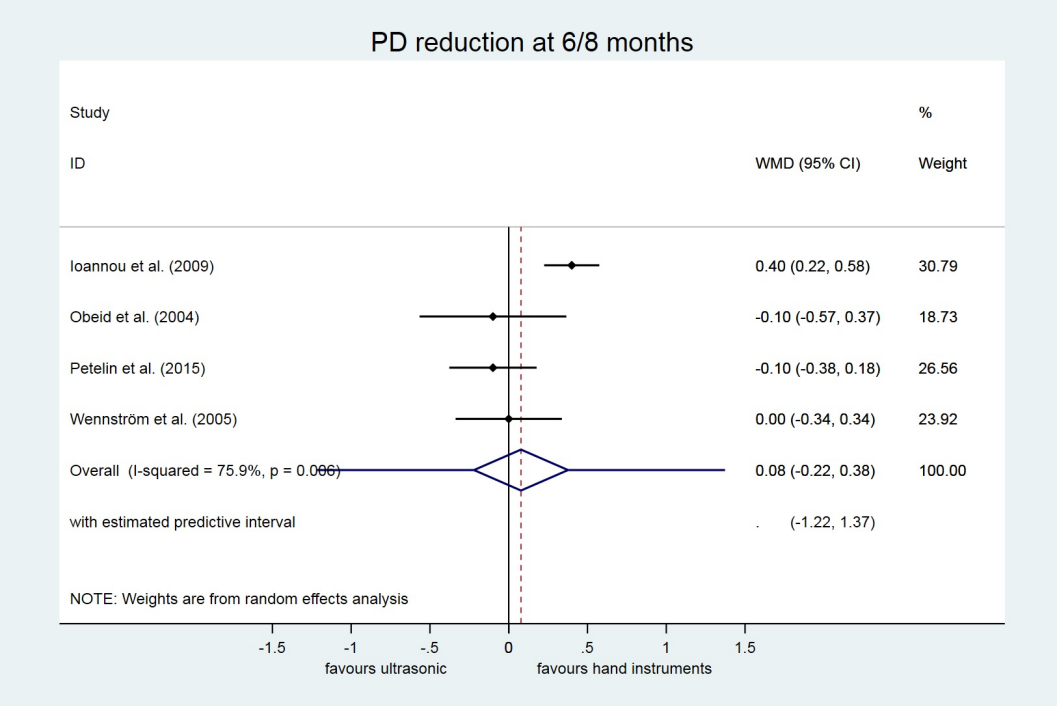

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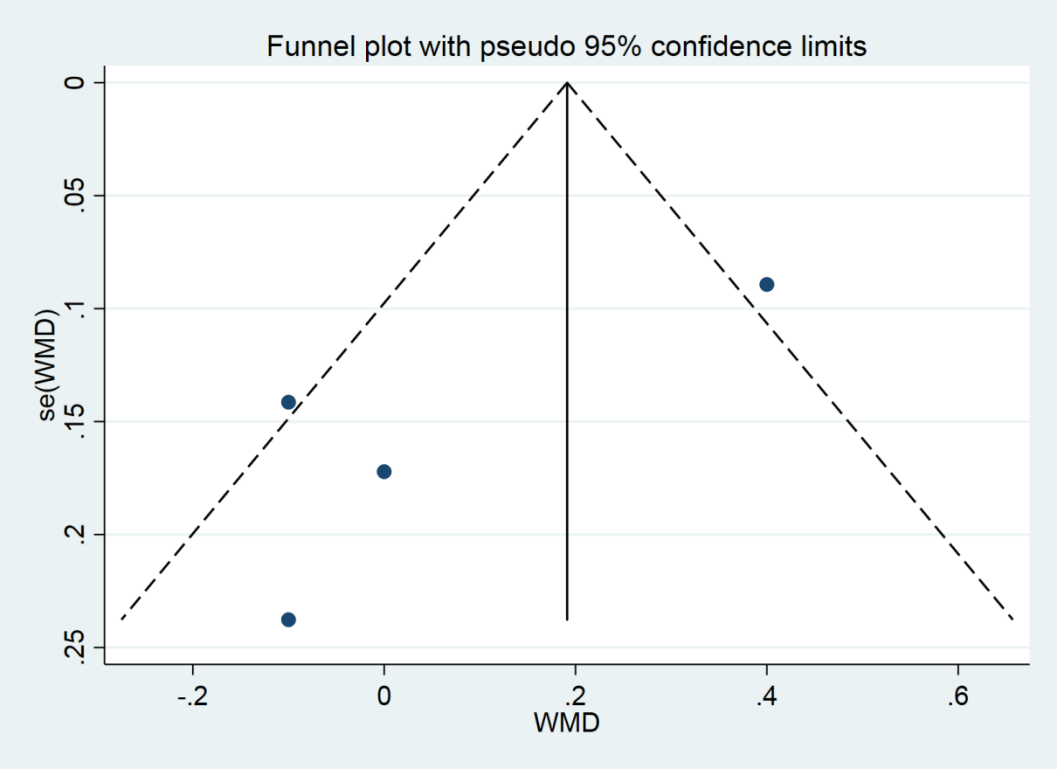

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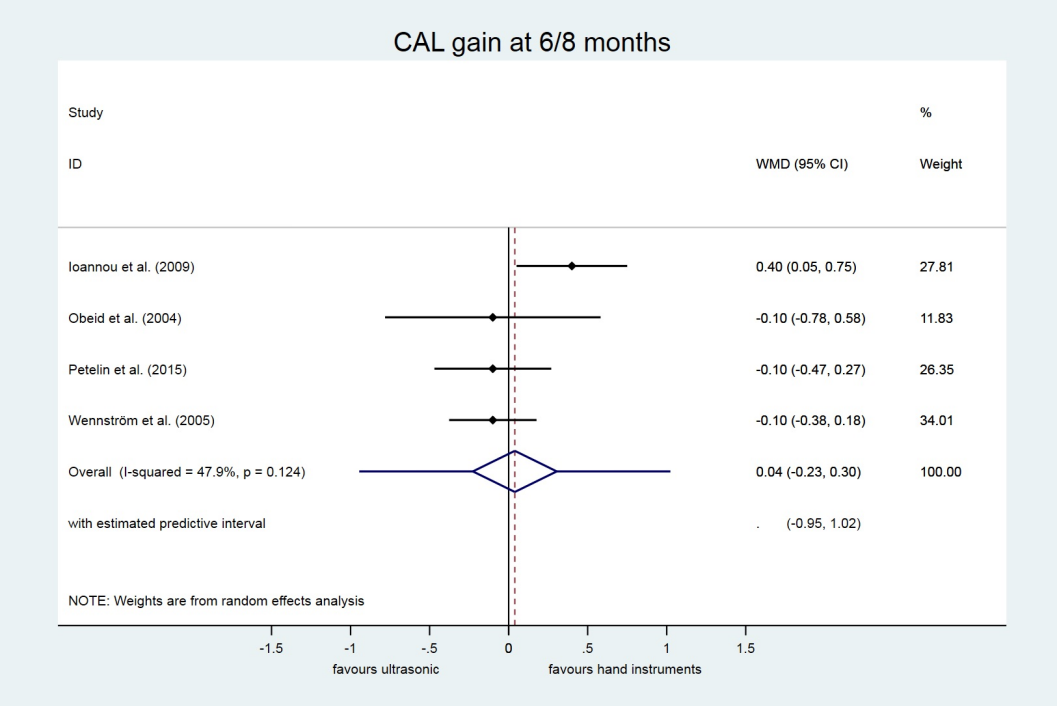

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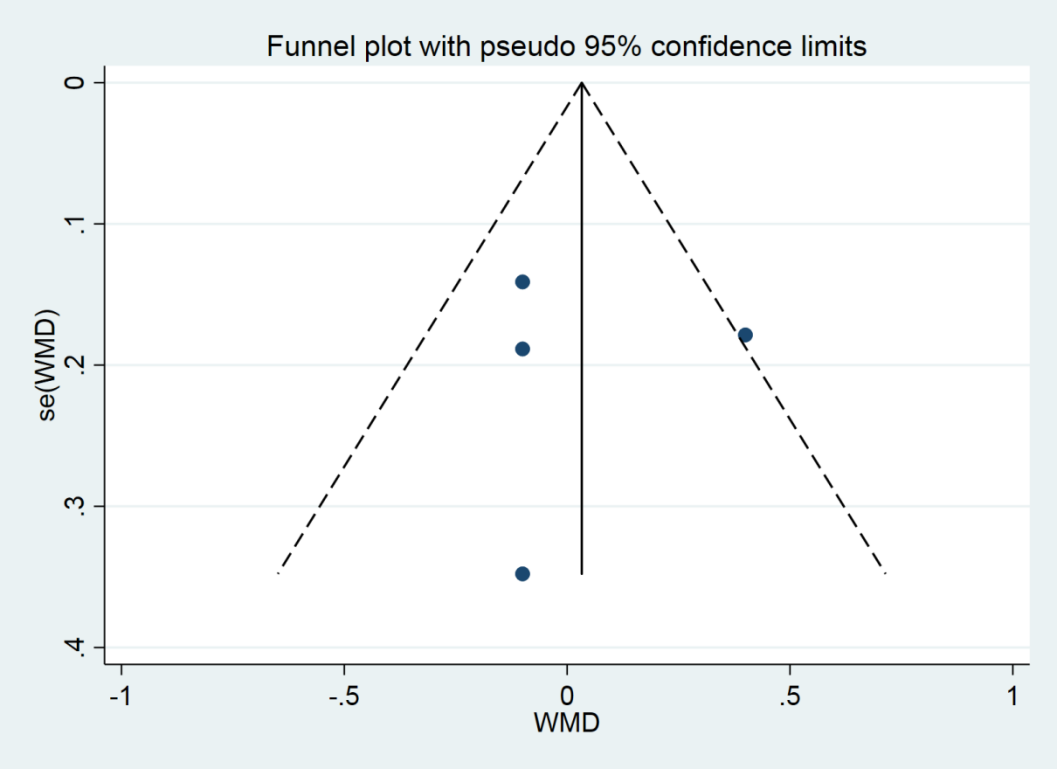

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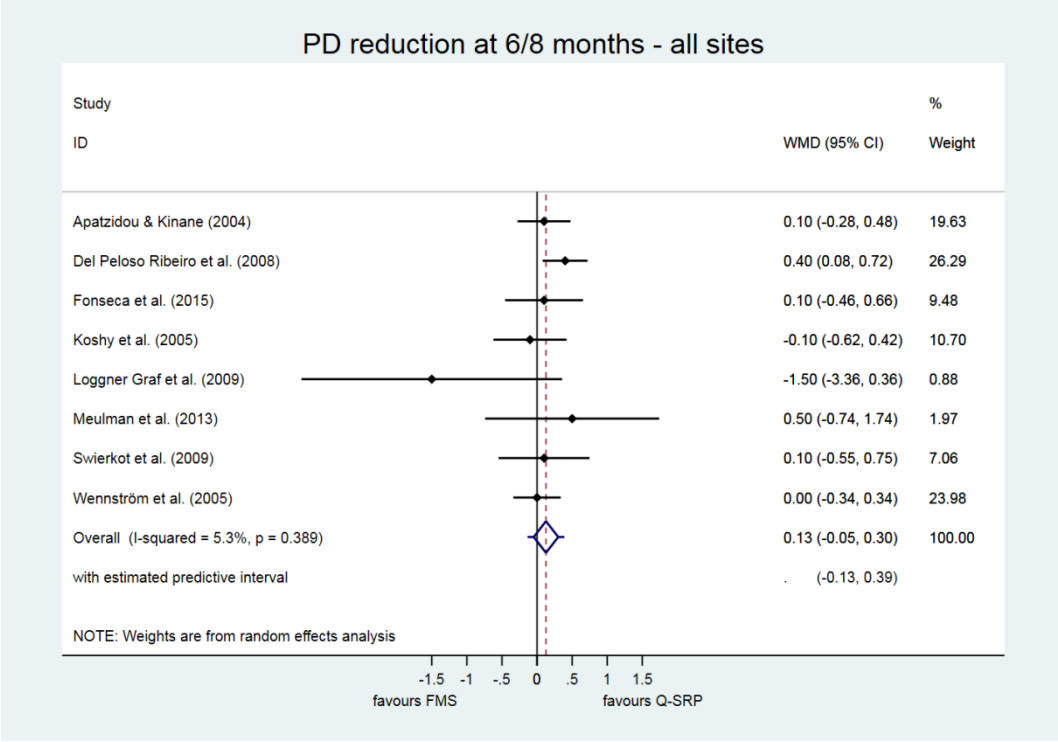

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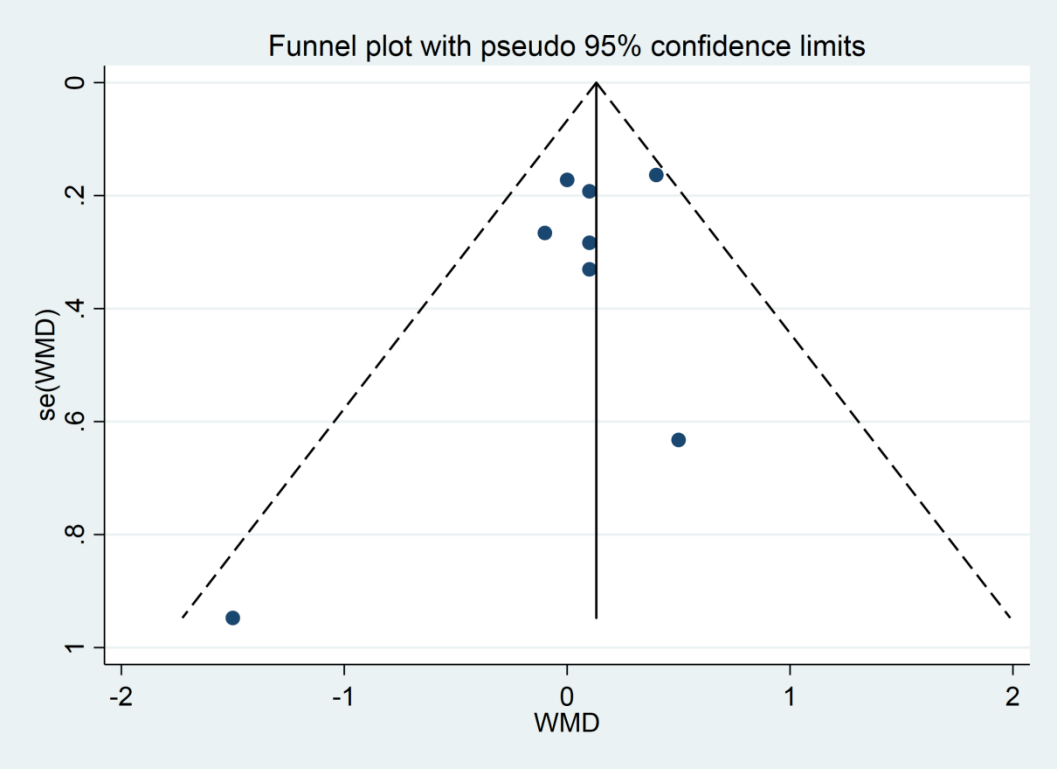

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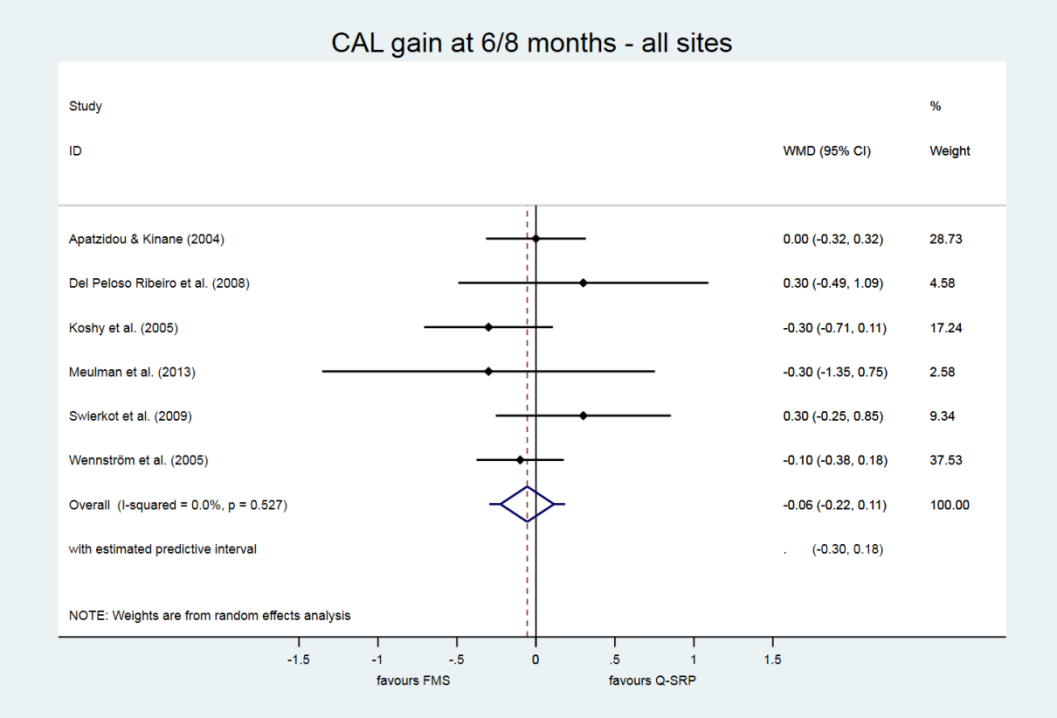

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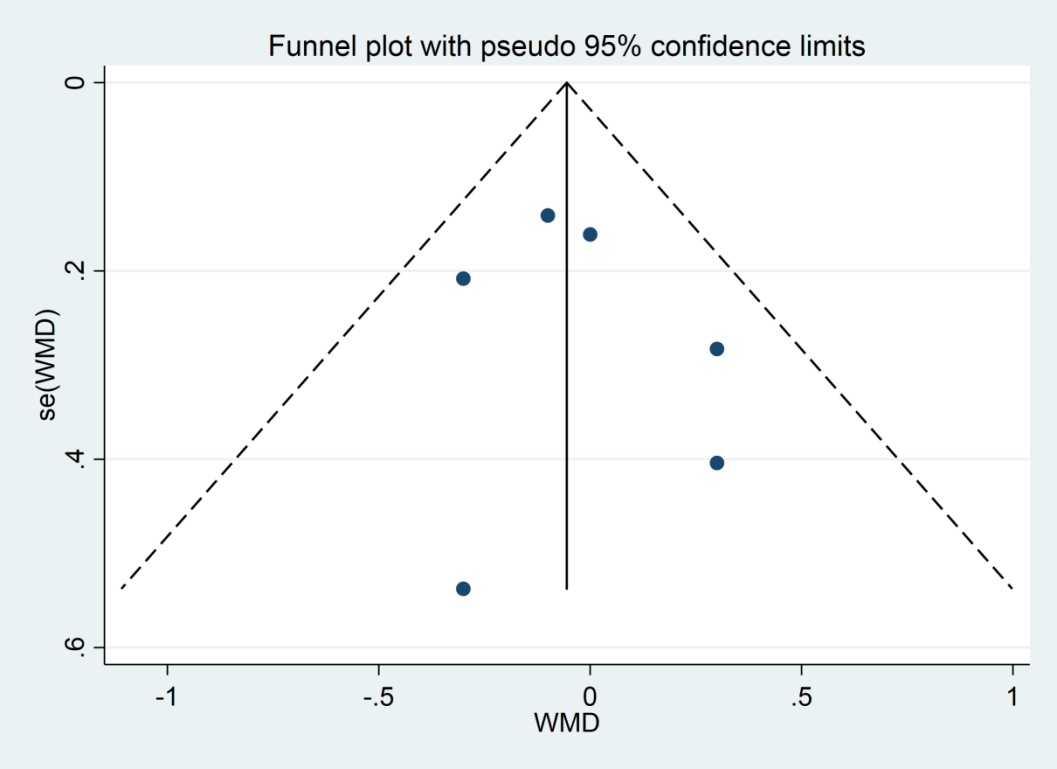

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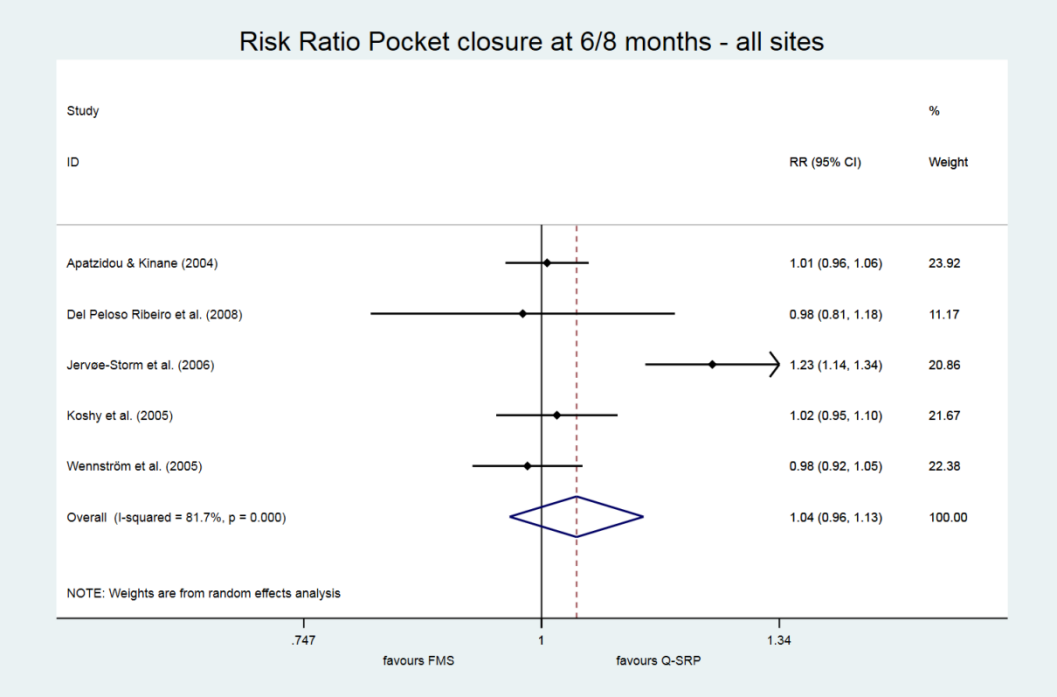

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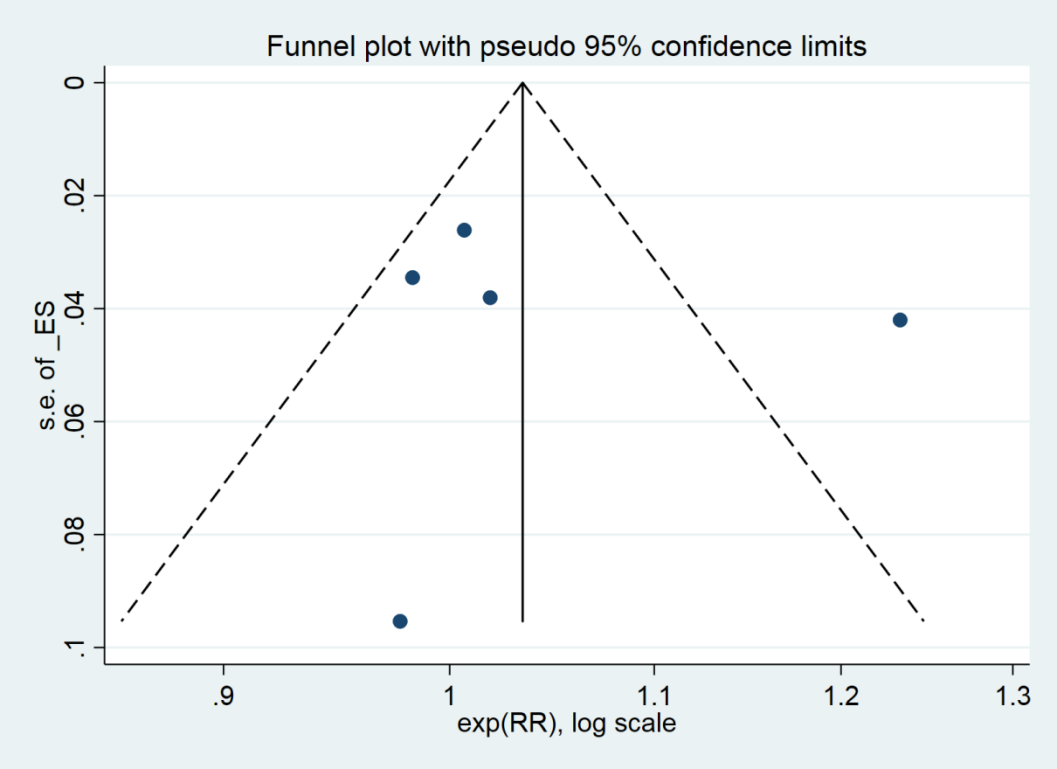

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