Comparison Between Hand and Sonic/Ultrasonic Instruments for Periodontal Treatment: Systematic Review with Meta-Analysis

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ABSTRACT

Aims: To systemically review the literature on the effect of hand and sonic/ultrasonic instruments used for the non-surgical treatment of periodontitis.

Material and methods: Five databases were searched for randomized clinical trials that compared the results of periodontal treatment using hand and sonic/ultrasonic for non-surgical periodontal treatment. Four meta-analyses were performed, using the calculated mean differences (MD) between baseline and 3-months or 6-months after periodontal treatment for clinical attachment level (CAL), and probing pocket depth (PPD).

Results: Eighteen studies were included. All included studies showed significant improvement, in at least one periodontal parameter, in both tested periodontal therapies. The sonic/ultrasonic instruments spend significantly less time in comparison to manual instrumentation. At both 3- and 6-months after periodontal therapy, no statistically significant differences were detected for CAL gain between therapies (MD; 95%CI: 0.05; -0.21–0.30 and -0.23; -0.59–0.12). Similarly, no statistically significant differences were detected for PPD reduction between therapies at 3-months of follow-up (MD; 95%CI: -0.03; -0.34–0.28). After 6-months, the PPD reduction was 0.21 (95%CI: -0.43–0.00, p=0.05).

Conclusions: Similar results may be expected for the periodontal treatment performed with hand and sonic/ultrasonic instruments. However, further studies with lower risk of bias are warranted.

Keywords: Scaling; root planing; ultrasonic therapy

Introduction

Based on the new classification for periodontal diseases (Papapanou *et al*., 2018), periodontitis is a chronic multifactorial inflammatory disease associated with dysbiotic plaque biofilms and characterized by progressive destruction of the tooth-supporting apparatus. Its primary feature includes the loss of periodontal tissue support, clinically manifested with clinical attachment loss, presence of periodontal pocket and gingival bleeding. Radiographically, periodontitis demonstrates alveolar bone loss. Currently, the treatment options for periodontitis include surgical and non-surgical therapies (Deas *et al*., 2016; Graziani *et al*., 2018; Laleman *et al*., 2017). Sharpened dental curettes or edged sonic or ultrasonic scalers are the most frequently used instruments for the treatment of periodontitis (Krishna and De Stefano, 2016). The treatment also consists of behavior changes of the patients, leading to better oral health care, in order to decrease the levels of tissue inflammation (Stenman *et al*., 2018).

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Subgingival removal and disruption of the biofilms are the main keys to promote healing conditions of periodontal tissues in patients with periodontitis. Debridement of subgingival pockets may be achieved with hand instruments, represented by curettes and files, or sonic/ultrasonic devices. Previous reviews have compared manual and sonic/ultrasonic devices for treatment of periodontal disease (Tunkel *et al.*, 2002; Arabaci *et al.*, 2007; Krishna and De Stefano, 2016), reporting a significant reduction in most clinical parameters with both instruments, but no statistically significant differences regarding the outcomes of periodontal clinical parameters. For deep pockets, some ultrasonic tip designs could facilitate the access to the pockets, when compared to hand curettes (Barendregt *et al.*, 2008). However, it is important to highlight that previous training is mandatory to use these devices (Arabici *et al.*, 2007; Krishna and De Stefano, 2016).

Different clinical studies have tried to address the comparison between manual and sonic/ultrasonic instruments in non-surgical periodontal therapy. Merging the results of such studies may give a clearer picture of the state of the art, helping clinicians in their clinical decision making. In this sense, an update of the previously published systematic review is necessary. Therefore, the present study aimed to systematically review the literature concerning the effect of periodontal treatment using hand and sonic/ultrasonic instruments.

Materials and Methods

The present study followed the PRISMA guideline for systematic reviews (Moher *et al.*, 2009). The following focused question is addressed in this article: "In patients with periodontitis, does the use of hand instrumentation in non-surgical periodontal therapy present additional improvement in periodontal clinical parameters when comparted to non-surgical periodontal therapy with sonic or ultrasonic instruments?"

The PICO question comprised patients with periodontitis (Patients), non-surgical periodontal therapy performed with sonic or ultrasonic instruments (Intervention), compared to hand instrumentation in non-surgical periodontal treatment (Comparison), and changes in clinical attachment level (CAL), probing pocket depth (PPD), and number of sites with bleeding on probing (BOP) (Outcome).

Search strategy

The search strategy was conducted in three databases (MEDLINE-Pubmed, Scopus, and EMBASE). The literature search was performed between 1961 to January, 17th 2020. In MEDLINE-Pubmed, the search strategy was described as below:

#1 - periodontal disease[Title/Abstract] OR periodontal diseases[MeSH Terms] OR periodontal treatment[Title/Abstract] OR periodontal therapy[Title/Abstract] OR periodontal intervention[Title/Abstract] OR periodontium[MeSH Terms] OR periodontics[MeSH Terms] OR periodontal repair[Title/Abstract] OR Root Planing[Title/Abstract] OR dental scaling[Title/abstract]

#2 –Ultrasonics[Mesh Terms] OR Ultrasonic Therapy[Mesh Terms] OR ultrasonic scaler[Title/abstract] OR ultrasonic instrumentation[Title/Abstract] OR ultrasonic instrument[Title/Abstract] OR Dental High-Speed Technique[Mesh Terms] OR sonic scaler[Title/abstract]

#3- hand[Title/abstract] OR manual[Title/abstract] OR curettes[Title/abstract] OR subgingival curettage[MeSH Terms] OR subgingival debridment[Title/Abstract]

#4 - #1 AND #2 AND #3

The SCOPUS, EMBASE, Science Direct, Web of Science and Cochrane Library databases had adapted search strategies. Hand searches were also performed in the following journals: Journal of Periodontology, Journal of Clinical Periodontology, The International Journal of Periodontics & Restorative Dentistry, and Journal of Periodontal Research. The list of references of all selected studies included at this phase and related narrative and systematic reviews were also searched for eligibility (Tunkel *et al.*, 2002; Oda *et al.*, 2004; Arabaci *et al.*, 2007; Costa *et al.*, 2007; Walmsley *et al.*, 2008; Krishna and De Stefano, 2016). Moreover, in order to detect the gray literature, an adaption of the abovementioned search was adopted for the Google Scholar database.

Selection criteria and risk of bias assessment

Studies were independently selected by two researchers (FWMGM and RPP). Firstly, title and abstract were screened for eligibility, and a third researcher (GPJL) was involved when discrepancies were observed. The full-text eligibility was performed using the same process as previously described. The kappa indexes between researchers were 0.96 and 0.98 for the screening of title/abstract and full-text, respectively.

In order to be included, the studies had to present all the following criteria:

- Randomized clinical trials;
- Studies that involved adults of at least 18 years old, diagnosed with periodontitis;
- In the test group, the individuals had to be treated with non-surgical scaling and root planing using sonic/ultrasonic instruments;
- In the control group, the periodontal treatment had to be performed with non-surgical scaling and root planing using manual instruments only;
- A minimum of 6-weeks follow-up;
- Individuals with periodontitis, regardless of the criteria used;

- The study had to perform at least two periodontal evaluations, including PPD, CAL or BOP.

No restriction, regarding language and date of publication, was impose. However, studies that presented any of following characteristics were excluded:

- Letters to the editors, observational, *in vitro*, animal model, and review studies;
- Studies that used any type of local or systemic adjunct to non-surgical periodontal treatment;
- Studies that reported only microbiological outcomes;

Data extraction

Two researchers independently performed the data extraction of all included studies (RPP and GPJL). It was used a spreadsheet in Excel specifically developed for this study. A third researcher (FWMGM) was involved only if any discrepancy was detected. The spreadsheet contained the following variables: authors, year of publication, country, follow-up, number of individuals in each experimental group, number of male/female in each experimental group, number of smokers in each group, periodontal diagnosis and treatment protocol, systemic condition (if any), mean age, and the results for the periodontal assessment of each experimental period that individuals were followed.

Risk of bias assessment

In this systematic review, the bias risk tool used for the randomized clinical trials was the criteria proposed by COCHRANE Collaboration (Higgins *et al.*, 2011). The process of randomization and blinding, allocation concealment, blinding of outcome assessment, partially reported outcome data, selective reporting of outcomes, and existence of other biases were performed by two reviewers (RPP e GPJL). A positive mark was given for an item when sufficient information was provided, indicating low risk of bias, and, a negative mark was used, for high risk of bias, in case of lack of information. When both low and high risk of bias could not be assessed, the item was classified as unclear

Statistical Analysis

Five separate meta-analyses were performed, considering the time necessary to treat, using both approaches, and the different periodontal parameters and follow-up periods. Data on mean difference and standard deviation were obtained or calculated from the selected studies. Mean difference (MD) between baseline and 3-months and baseline and 6-months after therapy for PPD and CAL parameters as well as time necessary to treat (in minutes) for each experimental group were calculated. In order to increase the number of included studies in the quantitative analyses, studies that used sonic and ultrasonic scaling were grouped. In these analyses, the control group was composed of those studies that used only manual instruments in treatment.

All meta-analyses were performed in the RevMan software (version 5.3 for Windows). The Q test assessed the heterogeneity, which was quantified by the I^2 statistics. The overall quality of the evidence for each of the meta-analyses was rated using the GRADE approach (Guyatt *et al.*, 2011).

Results

Studies selection

Among the 810 studies initially screened, 18 were included in the present systematic review. Figure 1 shows the flowchart of the studies, including the main reasons for exclusion. Table 1 demonstrates the main descriptive characteristics and results of the included studies.

Characteristics of included studies

All of the 18 included studies were RCTs with follow-up times ranging from 7 days to 2 years (Badersten *et al.*, 1981; Badersten *et al.*, 1984; Oosterwaal *et al.*, 1987; Laurell and Pettersson, 1988; Copulos *et al.*, 1993; Obeid *et al.*, 2004; Sculean *et al.*, 2004; Wennström *et al.*, 2005; Forabosco *et al.*, 2006; Guentsch *et al.*, 2006; Tomasi *et al.*, 2006; Kahl *et al.*, 2007; Aslund *et al.*, 2008; Ioannou *et al.*, 2009; Malali *et al.*, 2012; Meulman *et al.*, 2013; Petelin *et al.*, 2015; Arpağ *et al.*, 2017). In all studies, the included patients were systemically healthy, except in four studies, in which the systemic condition was not reported (Badersten *et al.*, 1981; Badersten *et al.*, 1984; Laurell and Pettersson, 1988; Tomasi *et al.*, 2006).

Smoking exposure was not reported in seven studies (Badersten *et al.*, 1981; Badersten *et al.*, 1984; Oosterwaal *et al.*, 1987; Laurell and Pettersson, 1988; Copulos *et al.*, 1993; Sculean *et al.*, 2004; Malali *et al.*, 2012), four studies did not include smokers (Forabosco *et al.*, 2006; Guentsch *et al.*, 2006; Petelin *et al.*, 2015; Arpağ *et al.*, 2017). In the remaining studies, both smokers and nonsmokers were included, and the number of smokers ranged from five to 20 participants.

The number of sessions used to treat ranged from one session of Full-Mouth-Debridement (Oosterwaal *et al.*, 1987; Obeid *et al.*, 2004; Sculean *et al.*, 2004; Kahl *et al.*, 2007; Aslund *et al.*, 2008; Arpağ *et al.*, 2017) to at least one session within one-week interval in the sonic/ultrasonic group (Badersten *et al.*, 1981; Badersten *et al.*, 1984; Copulos *et al.*, 1993; Forabosco *et al.*, 2006; Ioannou *et al.*, 2009; Malali *et al.*, 2012). Regarding the manual instruments, the number of sessions ranged from one (Oosterwaal *et al.*, 1987; Laurell and Pettersson, 1988; Obeid *et al.*, 2004; Sculean *et al.*, 2004; Kahl *et al.*, 2007; Aslund *et al.*, 2008; Arpağ *et al.*, 2017) to 6 (Badersten *et al.*, 1981; Badersten *et al.*, 1984; Copulos

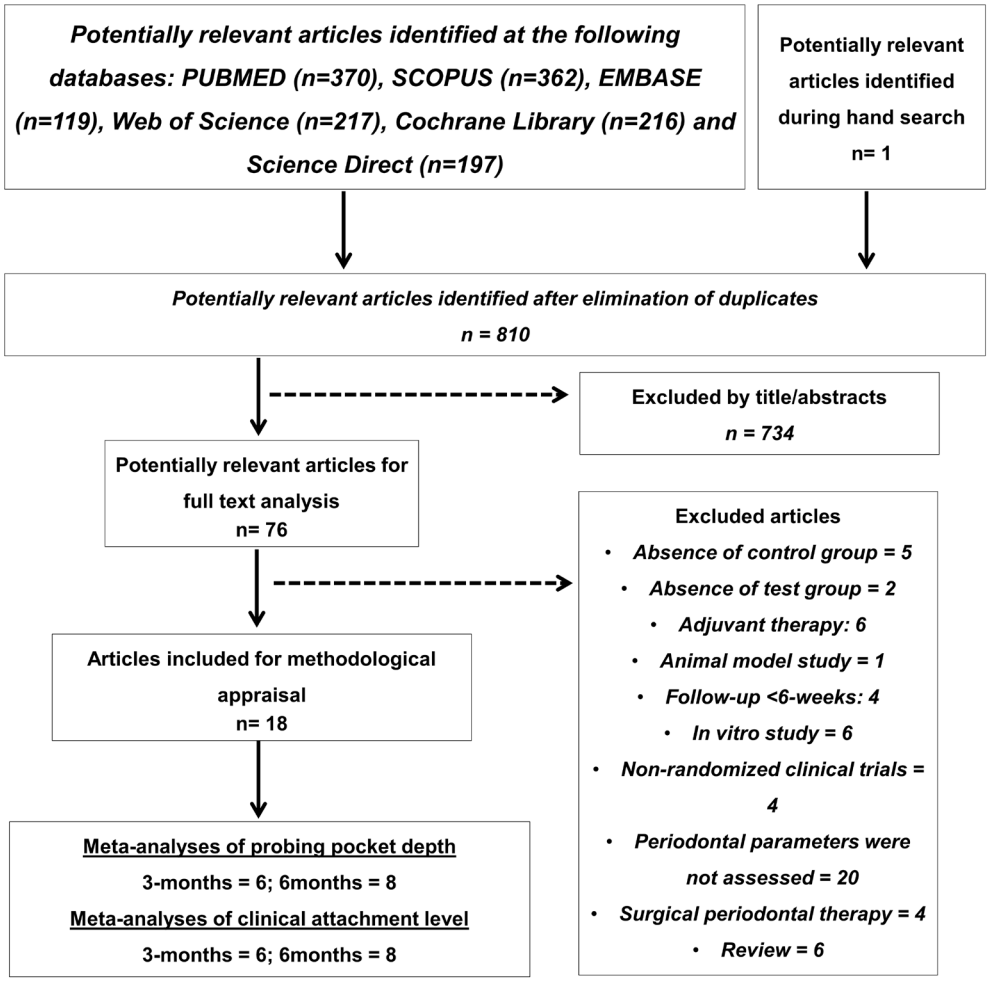

Figure 1. Flowchart of the study inclusion.

et al., 1993; Wennström *et al.*, 2005; Forabosco *et al.*, 2006; Tomasi *et al.*, 2006; Ioannou *et al.*, 2009; Malali *et al.*, 2012; Meulman *et al.*, 2013) sessions. The number of sessions was not clearly provided to both groups in one study (Petelin *et al.*, 2015). It is important to note, that, some of the studies performed re-intervention during the follow-up period.

Risk of bias assessment

Figure 2 shows the assessment of risk of bias. Overall, it was detected that all of the included studies showed high or unclear risk of bias in some methodological aspect. Overall, the blinding process presented the highest risk of bias, both in the blinding of participants and personnel and blinding of outcome assessment. This results could be influenced by the difficulty of camouflage the instruments used in the treatment process. The allocation concealment and the randomization process also showed high or unclear risk of bias in most of the included studies.

Qualitative results – Periodontal pocket depth

Periodontal pocket depth (PPD) reduction was reported in all the included studies. All the included studies showed that both manual and sonic/ultrasonic instruments reduced significantly PPD. Higher reductions were observed 90 days after the intervention, in studies that used this period of evaluation (Copulos *et al.*, 1993; Obeid *et al.*, 2004; Ioannou *et al.*, 2009), regardless of the treatment used. One study compared the effect of manual and sonic/ultrasonic treatment in PPD of single rooted or multi rooted teeth, and it was reported higher reduction of PPD in unirradicular when compared to multirradicular teeth for both treatments (Sculean *et al.*, 2004).

For comparisons between groups, almost all studies detected no statistically significant differences for PPD reduction. However, this was not the case in one study that demonstrated significantly higher PPD reduction in the ultrasonic group after 6-months of follow-up (Forabosco *et al.*, 2006). On the other hand, one study demonstrated significantly higher reduction of PPD in nonsmokers treated with manual instruments when compared to smokers that received ultrasonic subgingival instrumentation (Meulman *et al.*, 2013). No significant differences in PPD reduction were detected

Table 1. Main descriptive characteristics and results of the included studies.

Name, Year Study design Follow-up period	Systemic Conditions Smoking Status (n per group)	Sonic/ Ultrasonic devices used (n male – n female) Mean age	Manual instruments used (n male – n female) Mean age	Treatment protocol Sonic/ Ultrasonic group	Treatment protocol Manual group	Periodontal criteria of the included individuals	Main results	Time of instrumentation (mean time in minutes)
Arpağ, 2017 (RCT – Split mouth) 6 months	Systemically healthy Non-smokers	Vector ultrasonic system (18 Males – 12 Females) Mean age: 39.43±8.61	Gracey curetes (18 – Males – 12 Females) Mean age: 39.43±8.61	1 session	1 session	At least 2 teeth with ≥5mm PPD in each included quadrant.	PPD: No statistical significant difference was observed between groups after 6-months (p=0.693) BOP: N/R CAL: No statistical significant difference was observed between groups after 6-months (p=0.922).	N/R
Aslund, 2008 (RCT – Parallel) 2 months	Systematically healthy Smokers and non-smokers	Ultrasonic Piezo-ceramic 30 Patients (7 Males – 23 Females) Mean age: 49.7 7 Smokers	Gracey curettes 29 Patients (5 Males – 24 Females) Mean age: 51.5 7 smokers	1 session	1 session	Minimum of four ≥5mm pockets with 2mm CAL in different quadrants.	PPD: Sonic/ultrasonic: No statistically significant difference was observed between groups. BOP: N/R CAL: Sonic/ultrasonic: No significantly difference between the two treatment.	N/R
Badersten, 1981 (RCT – Split Mouth) 7 and 13 months	N/R N/R	Cavitron Model 600 unit with TF1-10 15 patients (N/R)	Ash TC 13/14 & Columbia 13/14 15 patients (N/R)	3 sessions of full-mouth-debridement	3 sessions	Periodontal bone loss amounting to one-third of the rooth length or more. Gingival inflammation and PPD ≥5mm deep. Calculus and bleeding upon probing present on 2 or more aspects of each tooth.	PPD: reduced from 4.1-4.5mm (baseline) to 1.3-1.7mm (final examination). No significant difference between groups (p>0.05). BOP: reduced from 77-99% (baseline) to 8-16% (final examination). CAL: minor changes occurred during the study. Deep pockets seemed to gain CAL at final examination.	Two operators were involved in each group. Manual group: 6.6 and 9.0 Sonic/Ultrasonic group: 4.9 and 8.5
Badersten, 1984 (RCT – Split mouth) 12 and 24 months	N/R N/R	Cavitron Model 600 unit with TF1-10 16 patients (11 Males – 5 Females) Age N/R	Ash TC 13/14 & Columbia 13/14 16 patients (11 Males – 5 Females) Age N/R	3 sessions	3 sessions	Periodontal bone loss amounting to one-third of the rooth length or more. Gingival inflammation and PPD ≥5mm deep. Calculus and bleeding upon probing present on 2 or more aspects of each tooth.	PPD: reduced from 5.5-5.8mm (baseline) to 3.6-3.9mm (final examination). No significant difference between groups (p>0.05). BOP: reduced from 84-90% (baseline) to 14-18% (12-months follow-up). No significant difference between groups (p>0.05). CAL: Limited changes occurred, At 24 months a mean gain of 0.1-0.3mm of CAL was observed. No significant difference between groups (p>0.05).	Two operators were involved in each group. Manual group: 9.4 and 12.5 Sonic/Ultrasonic group: 7.6 and 13.3

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Copulos, 1993 (RCT – Split Mouth) 45, 90 and 180 days	Systemically healthy N/R	Ultrasonic Scaler with modified Tip 9 Patients (7 Males – 2 Females) Mean age: 53.2 years	Gracey Curettes 9 Patients (7 Males – 2 Females) Mean age: 53.2 years	2 sessions	2 sessions	10 sites with PPD ≥ 3.0mm.	PPD: Sonic/ultrasonic – changes from baseline: 45 days (0.58±0.97); 90 days (0.62±1.18); 135 days (0.84±1.04); 180 days (0.72±1.09). Manual Changes from baseline: 45 days (0.40±1.02); 90 days (0.70±1.03); 135 days (0.58±1.27); 180 days (0.75±1.20). Comparison between groups (p>0.05). BOP: Sonic/ultrasonic – changes from baseline: 14 days 72.5%; 45 days 52.2%; 90 days 33.3%; 135 days 42.5% 180 days 46.7%. Manual – changes from baseline: 14 days 55.0%; 45 days 60.0%; 90 days 46.7%; 135 days 55.0%; 180 days 68.9%. Comparison between groups (p>0.05). CAL: Sonic/ultrasonic – mean reduction from baseline: 45 days (0.095±1.73); 90 days (0.043±1.50); 135 days (0.08±1.65; 180 days (0.10±1.71). Manual mean reduction from baseline: 45 days (0.75±1.42); 90 days (0.30±1.27); 135 days (0.52±1.34); 180 days (0.20±1.34). Comparison between groups (p>0.05).	Manual group: 5.9±2.1 Sonic/ultrasonic group: 3.9±1.2 P-value <0.05
Forabosco, 2006 (RCT - Parallel) 30, 90 and 120 days	Systemically healthy Only non-Smokers	Ultrasonic Odontoson M + NaCl2 20 Patients (NR)	Gracey Curettes 20 Patients (NR)	2 sessions	2 sessions	PPD ≥ 5mm and BOP around at least 7 teeth.	PPD: Sonic/ultrasonic group displayed a reduction of 20.6% from baseline to 120 days (P<0.028). Manual group displayed a reduction of 15.5% from baseline to 120 days. Comparison between groups (p<0.05) BOP: Sonic/ultrasonic group showed a reduction of 50% compared to baseline. Manual group showed a reduction of 40% compared to Baseline. CAL: both groups showed similar gains of CAL.	N/R
Guentsch, 2006 RCT – Parallel) 6 months	Systematically healthy Non-Smokers	Ultrasonic Vector 10 Patients (N/R)	Instrument N/R) 10 Patients (N/R)	1 Full-Mouth-Debridement (24-42 hours)	1 Full-Mouth-Debridement (24-42 hours)	PPD deeper than 5mm in at least 12 teeth.	PPD: Sonic/ultrasonic – 6-months 2.99±0.60mm. Manual – 6-months 2.64±0.49mm. Comparison between groups (P>0.05). BOP: Sonic/ultrasonic – 6-months 19.6±13.9. Manual – 6-months 13.8±14.5. Comparison between groups (P>0.05). CAL: Sonic/ultrasonic – From baseline to six months mean gained 1.85±0.99mm. Manual– From baseline to six months mean gained 2.66± 1.74mm. Comparison between groups (P>0.05).	N/R

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Ioannou, 2009 (RCT - Parallel) 3 and 6 months	Systemically healthy 17 Smokers (9 sonic/ultrasonic and 8 manual group) 23 Non- Smokers	Pexoeletric Ultrasonic Device 17 Patients (5 Male – 12 Female) Mean age: 50.47±2.58	Gracey Curettes 16 Patients (8 Male – 8 Female) Mean age: 49.62±2.07	3 to 4 sessions	3 to 4 sessions	Minimum of 4 sites with PPD ≥5mm in at least two quadrants with BOP.	PPD sonic/ultrasonic – 3 months 2.96±0.12mm; 6 months 3.05±0.14. Manual – 3 months 3.03±0.13mm; 6 months 3.03±0.19. Comparison between groups (p>0.05). GBI sonic/ultrasonic – 3 months 0.24±0.03; 6 months 0.33±0.05. Manual – 3 months 0.32±0.04; 6 months 0.33±0.05. Comparison between groups (p>0.05). CAL sonic/ultrasonic – 3 months 4.23±0.26; 6 months 4.32±0.21. Manual – 3 months 4.87±0.37; 6 months 4.78±0.40. Comparison between groups (p>0.05).	N/R
Kahl, 2007 (RCT – Split Mouth) 3 and 6 months	Systemically healthy 8 Smokers and 12 Non- Smokers	The Vector-ultrasonic system 20 patients (8 Males – 12 Females) Mean age: 47±9	Gracey Curettes 20 patients (8 Males – 12 Females) Mean age: 47±9	1 session	1 session	Two single-rooted teeth with a PPD between 5 and 8mm in each quadrant.	PPD: No statistically significant differences were found between sites treated with sonic/ultrasonic or manual devices. The mean PD reductions were higher in sites with deep initial PPD than sites with moderate pocket depth. BOP: No significant differences between groups was demonstrated (p>0.05). CAL: No significant differences between groups was demonstrated (p>0.05)	Sonic/ultrasonic: up to 6min Manual: up to 6 min
Laurell, 1988 (RCT – Split Mouth) 90 Days	N/R N/R	Titan-S sonic scaler 12 Patients (5 Male – 7 Female) Age: NR	N/R 12 Patients (5 Male – 7 Female) Age: NR	1 session	1 session	A minimum of 30 sites with PPD of 4-7mm;	PPD: Sonic/ultrasonic – 4-months 7±6 pockets. Manual –4-months 9±8 pockets. Comparison between groups (p>0.05). BOP: Sonic/ultrasonic – 4-months 11±9%. Manual – 4-months 15±9. Comparison between groups (p>0.05). CAL: Not assessed	Sonic/ultrasonic 8±3/tooth Manual 12±5/tooth P-value <0.05
Malali, 2012 (RCT - Parallel) 90 days	Systemically healthy N/R	Cavitron Bobcat Pro 10 Patients (NR) Mean age of whole sample – 48.83±7.23	Gracey Curettes 10 Patients (NR) Mean age of whole sample – 48.83±7.23	4 to 6 sessions (30-45 minutes)	4 to 6 sessions (30-45 minutes)	Four single-rooted teeth with radiographic bone loss. Two sites with PPD 4-6. Two sites with PPD ≥ 7mm,	PPD: Sonic/ultrasonic – 90 days 2.69±0.75mm. Manual – 90 days 2.25±0.39mm. Comparison between groups (p>0.05). BOP: Sonic/ultrasonic – 90 days 13.5±2.89%. Manual – 90 days 15.2±2.9%. Comparison between groups (p>0.05). CAL: Sonic/ultrasonic – 90 days 9.58±1.39mm. Manual – 90 days 8.89±0.90mm. Comparison between groups (p>0.05).	N/R

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Meulman, 2013 (RCT – Parallel) 45, 90 and 180 days	Systemically healthy 20 Smokers – 10 Non-smokers	Cavitron Dentsply 10 smokers (5 Male – 5 Female) Mean age: 42.25±4.75	Gracey Curettes N= 10 smokers (6 male – 4 female) and 10 Non-smokers (5 Male – 5 Female) Mean age: smokers: 43.40±7.38 Mean age non smokers: 45.60±4.84	1 Full-mouth-debridement	4 sessions	CAL of ≥ 5mm, BOP and radiographic bone loss. At least nine teeth wih PPD ≥5mm.	PPD: sonic/ultrasonic: Intra-group analysis demonstrated that Manual (smokers & non-smokers) group reduced more than sonic/ultrasonic group after 180 days (P<0.05). Smokers in sonic/ultrasonic group presented deeper pockets at 180 days compared to non-smokers (P>0.05). BOP: No differences between groups were observed at baseline, 45, 90 and 180 days (P>0.05). BOP reduced significantly over time as compared to baseline for all experimental groups. CAL: Analysis demonstrated that non-smokers gained more CAL regardless of the group (sonic/ultrasonic or manual) P<0.05). Inter-group comparisons showed that manual group (non-smokers) gained more CAL than sonic/ultrasonic (smokers or non-smokers) after 180 days P<0.05).	Sonic/ultrasonic – 45 min (full-mouth-desinfection) Manual: N/R
Obeid, 2004 (RCT – Split Mouth) 3 and 6 months	Systemically healthy 4 Smokers and 16 Non- Smokers	Ultrasonic Scaler – Suprasson P500 20 patients (10 Male – 10 Female) Mean age: 50.3±6.4	Gracey Curettes 20 patients (10 Male – 10 Female) Mean age: 50.3±6.4	1 session	1 session	At least two sites with PPD ≥4mm per multi-rooted teeth. At least three sites with PPD ≥ 4mm for all remaining teeth per quadrant.	PPD: sonic/ultrasonic – 3 months 3.8±0.5mm; 6 months 3.3±0.5mm. Manual – 3 months 3.9±0.4; 6 months 3.3±0.6mm. Comparison between groups (p>0.05). BOP: sonic/ultrasonic – 3 months 1.5±0.6; 6 months 1.0±0.7. Manual – 3 months 1.5±0.6; 6 months 0.9±0.6. Comparison between groups (p>0.05). CAL: sonic/ultrasonic – 3 months 8.6±0.6mm; 6 months 8.1±0.7mm. Manual – 3 months 8.7±0.6mm; 6 months 8.2±0.7mm. Comparison between groups (p>0.05).	Sonic/ultrasonic group: 2min/tooth Manual group – 3min/tooth
Oosterwall, 1987 (RCT – Split Mouth) 7, 21 and 49 days	Systemically healthy N/R	Dentsply Cavitron with TF1-10 12 patients (6 Male – 6 Female) Mean age: 37	Gracey Curettes 12 patients (6 Male – 6 Female) Mean age: 37	1 session	1 session	Presence of at least 6 periodontal pockets of 6-9mm at one rooted teeth with BOP. Alveolar blood loss and CAL.	PPD: No significant differences were found between groups. BOP: 49 days 29% (manual) and 22% (sonic/ultrasonic). No significant differences were found between groups. CAL: Not assessed.	N/R

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Table 1. continued ...

Petelin, 2015 (RCT) 3, 6, 9 and 12 months	Systemically healthy Only non-smokers	NSK Varios 970 9 Patients (4 Male – 5 Female) Mean age: 51	Gracey Curettes 9 Patients (6 Male – 3 Female) Mean age: 43	N/R	N/R	At least four teeth with PPD ≥4mm in each quadrant.	PPD: sonic/ultrasonic – 3 months 3.1±0.2; 6 months 3.1±0.2; 9 months 3.1±0.2; 12 months 3.0±0.2. Manual – 3 months 3.5±0.2; 6 months 3.4±0.2; 9 months 3.3±0.2; 12 months 3.3±0.2. Comparison between groups (p>0.05). BOP: sonic/ultrasonic – 3 months 16.5±2.6; 6 months 17.8±2.3; 9 months 13.5±1.5; 12 months 12.2±1.4. Manual – 3 months 10.5±2.6; 6 months 10.6±2.3; 9 months 7.8±1.5; 12 months 9.0±1.4 . Comparison between groups (p<0.05 only at 12-months of follow-up). CAL: sonic/ultrasonic – 3 months 3.7±0.3; 6 months 3.7±0.2; 9 months 3.8±0.3; 12 months 3.7±0.2. Manual – 3 months 4.4±0.3; 6 months 4.2±0.2; 9 months 4.0±0.3; 12 months 4.0±0.2. Comparison between groups (p>0.05).	N/R
Sculean, 2004 (RCT - Parallel) 6 months	Systemically healthy N/R	Vectort-ultrasonic system 19 Patients (9 Males – 10 Female) Mean age: 55	Gracey Curettes 19 Patients (8 Male – 11 Female) Mean age: 53 years	1 session	1 session	Patients with chronic periodontitis	PPD: There was a statistically significant reduction of PPD in both groups. No statistically significant difference was observed between groups. BOP: sonic/ultrasonic 60 months 20%. Manual 6 months 18%. Comparison between groups (p>0.05). CAL: There was a statistically significant gain of CAL at both groups, but no significantly difference between the two treatment.	Sonic/ultrasonic 6 minutes (Single rooted) and 10 min (multi rooted). Manual 8 minutes (single rooted) and 12 minutes (multi rooted).
Tomasi, 2006 (RCT Parallel) 1 year	N/R 16 Smokers - 8 sonic/ultrasonic and 8 Manual 21 Non- Smokers	EMS Piezon Master 400 – A1 PerioSlim tips 19 Patients (11 Male – 8 Female) Mean age: 47	Gracey Curettes 18 Patients (8 Male – 10 Female) Mean age: 53	1 hour Full-mouth-debridement	4 sessions	Remaining PPD of ≥5mm after 3-months of the first intervention.	PPD: sonic/ultrasonic 1 year 3.2. Manual 1 year 3.3. Comparison between groups (p>0.05). BOP: sonic/ultrasonic 1 year 35%. Manual 1 year 40%. Comparison between groups (p>0.05). CAL: Not assessed.	Overall time Sonic/ultrasonic 106min Manual 214min
Wennström, 2005 (RCT – Parallel) 3 and 6 months	Systemically healthy 20 Smokers – 11 Sonic/ultrasonic and 9 Manual 21 Non-Smokers	Piezoceramic ultrasonic EMS 400 20 Patients (12 Males – 8 female) Mean age: 51.7	Periodontal curetes 21 Patients (10 Male – 11 Female) Mean age: 47.8	1 Full-mouth-debridement	4 sessions	At least eight teeth must show probing pocket depths (PPD) of ≥5mm and bleeding on probing (BOP). At least two of these teeth must have a PPD of ≥7 mm.	PPD: sonic/ultrasonic – 3 months 4.4±0.5mm; 6 months 4.0±0.5mm. Manual – 3 months 4.3±0.5mm; 6 months 4.0±0.5mm. Comparison between groups (p>0.05). BOP: sonic/ultrasonic – 3 months 29%; 6 months 23%. Manual – 3 months 32%; 6 months 24%. Comparison between groups (p>0.05). CAL: sonic/ultrasonic – 3 months gain 1.3±0.5mm; 6 months gain 1.6±0.4. Manual – 3 months gain 1.2±0.40; 6 months gain 1.3±0.5mm. Comparison between groups (p>0.05).	Sonic/ultrasonic 3.3±1.4min Manual 8.8±5.1min P-value <0.05

Legend: RCT- Randomized Clinical Trial; N/R- Not Reported; PPD: probing pocket depth; BOP: bleeding on probing; CAL: clinical attachment level.

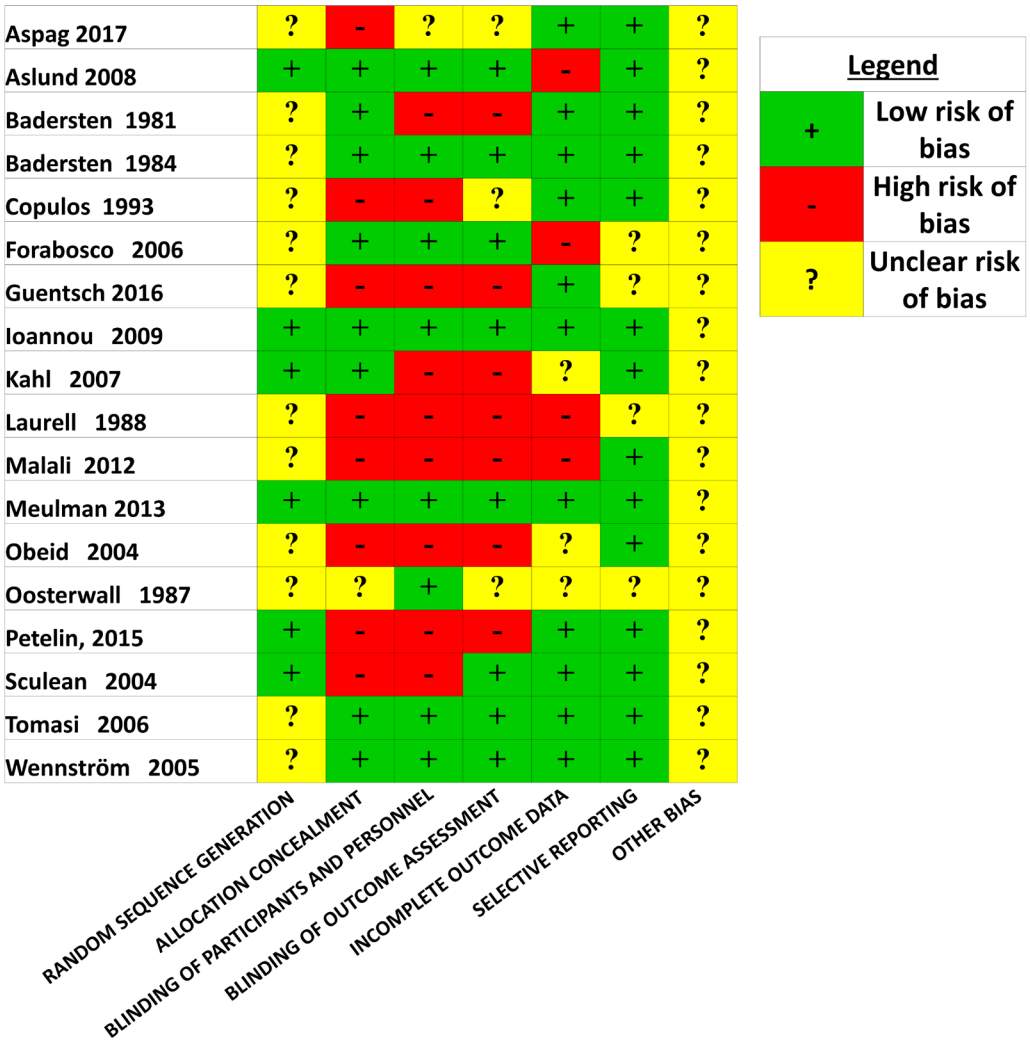

Figure 2. Risk of bias assessment of the included studies.

for smokers treated with manual or ultrasonic devices (Meulman *et al.*, 2013). When different degrees of PPD were evaluated, higher reductions were demonstrated in deep pockets when compared to shallow and moderate pockets (Oosterwaal *et al.*, 1987; Sculean *et al.*, 2004).

Qualitative results – Clinical attachment level

Clinical attachment level (CAL) gain was reported in most of the studies after treatment in both groups (Badersten *et al.*, 1984; Copulos *et al.*, 1993; Obeid *et al.*, 2004; Sculean *et al.*, 2004; Christgau *et al.*, 2006; Forabosco *et al.*, 2006; Guentsch *et al.*, 2006; Tomasi *et al.*, 2006; Kahl *et al.*, 2007; Ioannou *et al.*, 2009; Malali *et al.*, 2012; Meulman *et al.*, 2013; Arpağ *et al.*, 2017). Within groups, CAL improved significantly for both types of instrumentation. For the comparison between groups, no statistically significant differences were observed after treatment in all studies that reported this outcome. When the initial PPD were considered, deep pockets presented significantly higher attachment gain when compared to moderate and shallow pockets for all tested treatments (Sculean *et al.*, 2004).

Qualitative results – Bleeding on probing

When the whole-mouth was considered, almost all of the included studies demonstrated no significant difference in the reduction of sites with BOP (Badersten *et al.*, 1981; Badersten *et al.*, 1984; Oosterwaal *et al.*, 1987; Laurell and Pettersson, 1988; Obeid *et al.*, 2004; Sculean *et al.*, 2004; Forabosco *et al.*, 2006; Guentsch *et al.*, 2006; Tomasi *et al.*, 2006; Kahl *et al.*, 2007; Malali *et al.*, 2012; Meulman *et al.*, 2013; Petelin *et al.*, 2015). Only one study demonstrated significantly lower reduction of BOP in the groups that used the ultrasonic devices after 6-months of follow-up (Copulos *et al.*, 1993). Due to the high heterogeneity of the studies data, a meta-analysis was not possible to be performed for this outcome.

Qualitative results – Time to treat using the devices

Six of the included studies assessed the mean time to treat periodontitis using both devices (Badersten *et al.*, 1981; Badersten *et al.*, 1984; Laurell and Pettersson, 1988; Copulos *et al.*, 1993; Sculean *et al.*, 2004; Wennström *et al.*, 2005;). Among them, six studies demonstrated

that ultrasonic/sonic devices demanded less time than manual instrumental (Badersten *et al.*, 1981; Badersten *et al.*, 1984; Copulos *et al.*, 1993; Laurell and Pettersson, 1988; Sculean *et al.*, 2004; Wennström *et al.*, 2005), of which only three of them provided statistical analysis for this outcome (Laurell and Pettersson, 1988; Copulos *et al.*, 1993; Wennström *et al.*, 2005).

Meta-analyses for alterations in probing pocket depth

Figure 3(a) presents the meta-analysis for PPD alteration between baseline and 3-months after therapy. Six studies were included in this analysis (Copulos *et al.*, 1993; Obeid *et al.*, 2004; Wennström *et al.*, 2005; Ioannou *et al.*, 2009; Malali *et al.*, 2012; Petelin *et al.*, 2015), and a pooled MD of -0.03 mm (95%CI: -0.34 – 0.28) was demonstrated, with no statistically significant difference between groups. This meta-analysis showed a high heterogeneity (I^2, $p<0.001$).

Eight studies were included in the meta-analysis for PPD reduction between baseline and 6-months (Copulos *et al.*, 1993; Obeid *et al.*, 2004; Sculean *et al.*, 2004; Wennström *et al.*, 2005; Guentsch *et al.*, 2006; Ioannou *et al.*, 2009; Petelin *et al.*, 2015; Arpağ *et al.*, 2017) (Figure 3b). In this analysis, a discrete but significant difference between groups was detected (MD; 95%CI: -0.21; -0.43 – 0.00, $p=0.05$) (Figure 3b). This analysis showed an I^2 of 97% ($p<0.001$).

Meta-analyses for alterations in clinical attachment level

Figure 4(a) and 4(b) show the alteration of CAL between baseline and 3-months and baseline and 6-months, respectively. Six and eight studies, respectively, were included in the 3- (Copulos *et al.*, 1993; Obeid *et al.*, 2004; Wennström *et al.*, 2005; Ioannou *et al.*, 2009; Malali *et al.*, 2012; Petelin *et al.*, 2015) and 6-months analyses (Copulos *et al.*, 1993; Obeid *et al.*, 2004; Sculean *et al.*, 2004; Wennström *et al.*, 2005; Guentsch *et al.*, 2006;-Ioannou *et al.*, 2009; Petelin *et al.*, 2015; Arpağ *et al.*, 2017). Both analyses showed no statistically significant differences between groups (MD; 95%CI: 0.05; -0.21 – 0.30 and -0.23; -0.59 – 0.12, respectively). High heterogeneities were detected.

Meta-analyses for time to treat using the devices

For this meta-analysis, only three studies provided sufficient information to be included (Laurell and Pettersson, 1988; Copulos *et al.*, 1993; Wennström *et al.*, 2005). Overall, ultrasonic instruments demand significantly less time when compared to manual instruments (MD: -3.73; 95%CI: -6.03 – -1.43). This analysis also showed a high heterogeneity (I^2: 67%, $p<0.01$) (Figure 5).

Quality of evidence at the review level.

The GRADE quality of evidence of all meta-analyses performed are presented in Table 2. To all outcomes assessed, the quality of evidence was rated as very low, meaning that the true effect is likely to be substantially different from the estimate of effect.

Discussion

The present study aimed to systematically review the literature concerning the efficacy of hand and sonic/ultrasonic instruments used for the treatment of periodontitis. The literature related to this comparison presented a peak of publication in 1980. These studies were performed with powered scaling systems with technologies different from the ones available currently. After the year 2000, some clinical studies also revisited the theme and therefore, an updated systematic review is warranted, especially due to the existence of new powered technologies for scaling and root planing, as well as study designs with higher potential to generate evidence. The present study gathered both sonic and ultrasonic devices when comparing with manual devices. This strategy was based on the fact the only one of the included studies used sonic instruments (Laurell and Pettersson 1988), while the other included studies used ultrasonic devices. This systematic review summarizes data from the literature, in an attempt to possible help a clinical decision-making process. However, it is important to highlight that higher risk of bias were demonstrated in most of the included studies. The high risk of bias may limit the direct application of this information in a clinical basis.

Regarding PPD, all included studies showed significant reduction of this clinical parameter, and the majority showed no significant difference between groups. The meta-analysis for PPD reduction after 3-months and 6-months of treatment showed pooled MD of -0.03mm (95%CI: -0.34 – 0.28) and -0.21mm (95%CI: -0.43 – 0.00), respectively. The analysis of 3-months follow-up did not show significant differences between the tested groups and presented high heterogeneity. However, a modest higher PPD reduction may be expected when manual instruments are used. The borderline p-value and the high heterogeneity must be considered when interpreting this result. Additionally, in relation to CAL gain, all the included studies that assessed this outcome showed significant improvement in this clinical parameter. There were no statistically differences between treatment groups. Meta-analysis comparing baseline and 3- and 6-months after treatment showed no significant differences between groups with pooled MD of 0.05mm and -0.23mm, respectively. When interpreting these results, it must be taking into account that most of the included studies presented a high risk of bias in several of the evaluated criteria.

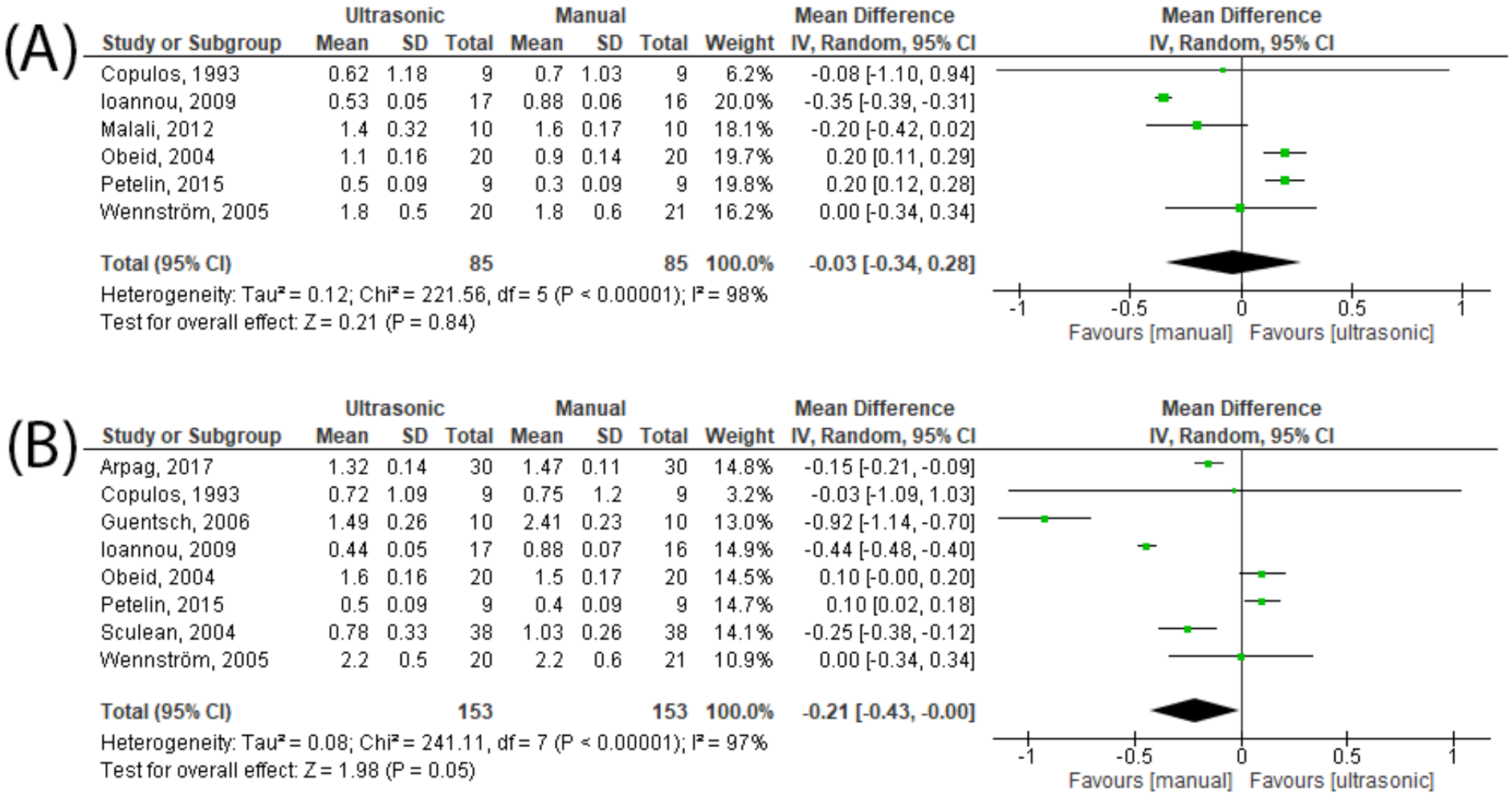

Figure 3. Forest plot for the mean difference in probing pocket depth from baseline to 3-months (A) and to 6-months (B).

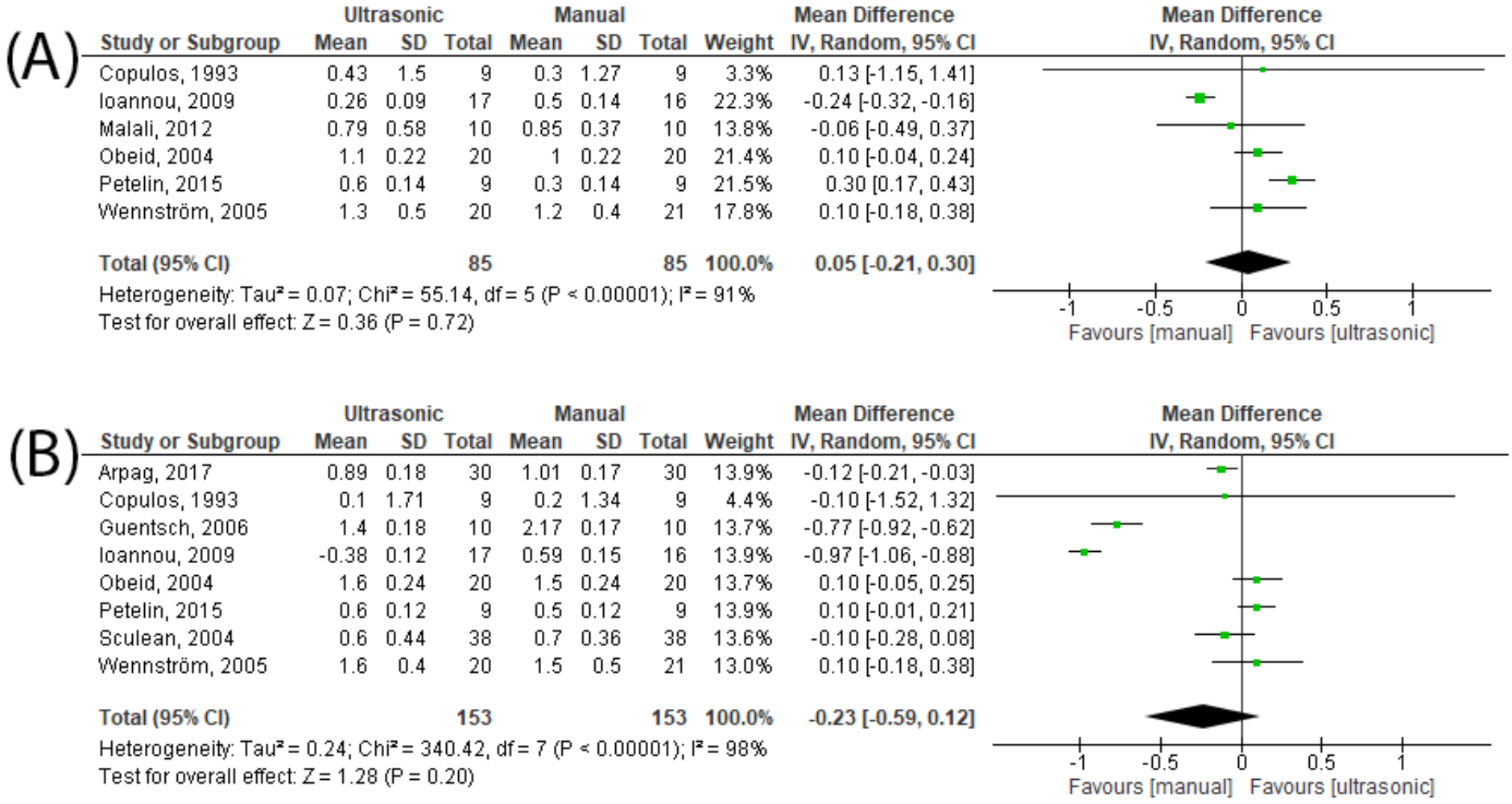

Figure 4. Forest plot for the mean difference in clinical attachment gain from baseline to 3-months (A) and to 6-months (B).

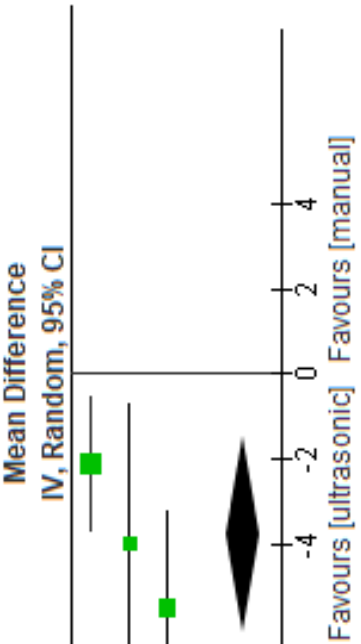

Figure 5. Forest plot for the mean time to treat comparing both manual and sonic/ultrasonic devices.

Non-surgical periodontal treatment is mainly performed either by hand instruments, or with power-driven instruments, mainly sonic or ultrasonic scalers. The choice of what kind of instrumentation to be used is mainly based on the operator preferences. The sonic and ultrasonic scalers were originally designed for gross scaling and supragingival calculus removal (Kamath and Umesh Nayak, 2014). However, studies have shown that subgingival instrumentation can be achieved with power-driven scalers in a comparable way to hand instruments (Oosterwaal *et al.*, 1987; Kamath and Umesh Nayak, 2014). In fact, despite the importance of the subject, since it is related to a day-to-day clinical activity, the number of high quality studies comparing both approaches, under contemporary approaches is limited. This is especially true since power-driven instruments present an important evolution with innovative equipment.

In 2002, a systematic review found no differences in clinical parameters between sonic/ultrasonic and manual debridement in the treatment of chronic periodontitis for single-rooted teeth (Tunkel *et al.*, 2002). Clinical studies comparing these modalities of treatment were published after this systematic review (Wennström *et al.*, 2005; Guentsch *et al.*, 2006; Tomasi *et al.*, 2006; Kahl *et al.*, 2007; Aslund *et al.*, 2008; Meulman *et al.*, 2013; Arpağ *et al.*, 2017). In this sense, there is a necessity to update the evidence regarding periodontal therapy with manual and sonic/ultrasonic instruments.

A recently published systematic review evaluated the efficacy of sonic, ultrasonic and hand instruments to treat periodontitis (Suvan *et al.*, 2019). This study also reported no significant difference in periodontal parameters after the use of manual or sonic/ultrasonic instruments. However, the strict inclusion criteria, allowed the inclusion of only six studies. Moreover, this systematic review did not assess the time necessary to treat when using these devices, as demonstrated in the present study. In the meantime, the results reported in the mentioned systematic review (Suvan *et al.*, 2019) are similar to the present study as they showed reduced levels of PPD, BOP and CAL in both types of treatments.

Different modalities of periodontal treatment, with different instruments, were proposed by the included studies in the present study. Conventional therapy through manual instrumentation was performed in all studies. Almost all the included studies specified the use of Gracey curettes. However, two of them did not provide sufficient information of what hand instrument was used (Laurell and Pettersson, 1988; Wennström *et al.*, 2005) and, two other studies reported having used manual instruments according to the operators preference, being Ash TC or Columbia curettes (Badersten *et al.*, 1981; Badersten *et al.*, 1984). Regarding the sonic/ultrasonic devices, eight different equipment were used

Table 2. Summary of the quality assessment to all outcomes included in the meta-analyses

Certainty assessment							Summary of findings					
Nº of studies	**Study design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**	**Hand instruments**	**Sonic or ultrasonic instruments**	**Relative (95% CI)**	**Absolute (95% CI)**	**Certainty**	**Importance**
PPD at 3-months of follow-up												
6	randomized trials	Very serious [a]	Very serious [b]	Not serious	Serious [c]	None	85	85	-	Mean 0.03 lower (0.34 lower to 0.28 higher)	⊕∘∘∘ VERY LOW	CRITICAL
PPD at 6-months of follow-up												
8	randomized trials	Very serious [a]	Very serious [b]	Not serious	Serious [c]	None	153	153	-	Mean 0.21 lower (0.43 lower to 0)	⊕∘∘∘ VERY LOW	CRITICAL
CAL at 3-months of follow-up												
6	randomized trials	Very serious [a]	Very serious [b]	Not serious	Serious [c]	None	85	85	-	Mean 0.05 higher (0.21 lower to 0.30 higher)	⊕∘∘∘ VERY LOW	CRITICAL
CAL at 6-months of follow-up												
8	randomized trials	Very serious [a]	Very serious [b]	Not serious	Serious [c]	None	153	153	-	Mean 0.23 lower (0.59 lower to 0.12 higher)	⊕∘∘∘ VERY LOW	CRITICAL
Time to treat using the devices												
3	randomized trials	Very serious [a]	Very serious [b]	Not serious	Very serious [c]	None	41	42	-	Mean 3.73 lower (6.03 lower to 1.43 lower)	⊕∘∘∘ VERY LOW	CRITICAL

Legend: CI: Confidence interval; MD: Mean difference; OR: Odds ratio
Explanations: a. Both studies presented a high risk of bias in several criteria. b. A high heterogeneity was detected. c. There is a moderate to high variability in the results found.

in the included studies, as demonstrated in Table 1. Dentsply® - Cavitron® Model with subgingival tips was the most used scaler among the studies (Badersten *et al.*, 1981; Badersten *et al.*, 1984; Oosterwaal *et al.*, 1987; Malali *et al.*, 2012; Meulman *et al.*, 2013), followed by Vector™ ultrasonic system (Sculean *et al.*, 2004; Guentsch *et al.*, 2006; Kahl *et al.*, 2007; Arpağ *et al.*, 2017), EMS Piezon® (Wennström *et al.*, 2005; Tomasi *et al.*, 2006; Ioannou *et al.*, 2009), and NSK VARIOS 970 (Petelin *et al.*, 2015), Titan-S sonic scaler (Laurell and Pettersson, 1988), Odontoson M® ultrasonic scaler (Forabosco *et al.*, 2006), Suprasson-P500® (Obeid *et al.*, 2004), Electro Medical Systems (Aslund *et al.*, 2008). One study did not specify the model of equipment used, but mentioned only as ultrasonic scaler (Copulos *et al.*, 1993). A comparison of results regarding the different powered-driven systems is not possible. However, in general, the results do not indicate that there is a relevant difference between different systems. By the way, in clinical results, the evolution of powered-systems seems not to be able to generate an additional benefit.

Sonic scalers, such as Sonicflex™ and Titan-S, operate at a frequency of 3,000 to 8,000 hertz (i.e., cycles per second; Hz). They attach to the dental unit's high-speed handpiece tubing and are driven by compressed air. Moreover, ultrasonic units are available in two types: magnetostrictive and piezoletric (Krishna and De Stefano, 2016). The magnetostrictive units are Cavitron®, Odontoson M®, Suprasson-P500®, Profi I Dabi Atlante, which operate between 18 kHz and 45 kHz. In all those instruments, the energy is converted to vibrations from the elliptical stroke patterns of the units metal rod or stack of metal sheets. All surfaces of the tip are active in the removal of calculus or plaque (Krishna and De Stefano, 2016). Piezoelectric units, such as Vector™ ultrasonic system and EMS Piezon®, operate in a range of 25 kHz to 50 kHz and strokes occur in a linear pattern via crystals activated by the ceramic handpiece. Only the lateral sides are effective in the removal of calculus (Arabaci *et al.*, 2007; Yousefimanesh *et al.*, 2012). Despite those differences in the kinematics of the instruments, studies investigating the clinical and microbiological efficacy of sonic and ultrasonic devices in the periodontal therapy also showed no significant differences between the instruments (Loos *et al.*, 1987; Derdilopoulou *et al.*, 2007). Therefore, in the present study, both sonic and ultrasonic instruments were gathered in the same group.

One of the main goals of periodontal therapy is to remove as much subgingival biofilm as possible to reduce the bacterial load to a point where the host can maintain tissue integrity, allowing periodontal healing (Cobb, 1996; Van der Weijden and Timmerman, 2002). In this sense, the literature has highlighted the importance of obtaining adequate root surface smoothness to achieve adequate soft tissue healing (Corbet *et al.*, 1993; Schwarz *et al.*, 1993). The rationale for this is that a rougher surface would be more easily and quickly recolonized by microorganisms. Additionally, studies have demonstrated that supragingival rough surfaces are associated with higher levels of dental plaque and gingivitis (Quirynen and Bollen, 1995; Leknes *et al.*, 1996).

The literature shows that sonic and ultrasonic instruments are more ergonomic when compared to hand instruments, but this issue is possibly mitigated when the operators increase their experience (Graetz *et al.*, 2016). It must be highlighted that the level of experience is very important in order to increase the biofilm removal when using these devices (Graetz *et al.*, 2017).

The present study tried to assess if powered-driven instruments really save time, which would be an interesting characteristics. In general, professionals spend more time in manual instrumentation. Since the possible better ergonomic characteristics of the powered-driven instruments, it would be interesting to test both preference of professionals as well as physical effort/fatigue as important outcomes.

It should be highlighted that the included studies in this review, in general, had high levels of risk of bias. This should be taking into consideration in the interpretation of the results. On the other hand, in general, groups and interventions were comparable. Due to the low number of studies in all meta-analyses, we could not assess the high heterogeneity detected. This may be one of the weakness of the present study. However, the different designs and manufactures of the instruments and the different criteria to diagnose periodontitis may partially explain the heterogeneity. Moreover, few studies reported the presence of side effects after periodontal therapy was performed. Therefore, further clinical studies are necessary, assessing this outcome and reducing the risk of bias. It should also be advised that patient-centered outcomes should assess the perception of patients about both therapeutic approaches.

Conclusion

From the present study it was concluded that both manual and powered-driven instruments are effective in the treatment of periodontitis. However, the use of manual instruments may be more time-consuming. Further randomized clinical trials, with lower risk of bias are warranted in order to better support the clinical decision making process.

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