# Treating periodontitis-A systematic review and meta-analysis comparing ultrasonic and subgingival hand scaling at different pocket probing depths.

**Xin Zhang**
Central South University Xiangya Stomatological Hospital
**Zixuan Hu**
Central South University Xiangya Stomatological Hospital
**Xuesong Zhu**
Central South University Xiangya Stomatological Hospital
**Jun Chen** ( chenjun1222@csu.edu.cn )
https://orcid.org/0000-0003-3265-0318
**Wenjie Li**
Central South University Xiangya Stomatological Hospital

Research article

**Keywords:** subgingival curettage; ultrasonic therapy; periodontal pocket; periodontal debridement; meta-analysis

**Posted Date:** August 26th, 2019

**DOI:** https://doi.org/10.21203/rs.2.13066/v1



**Version of Record:** A version of this preprint was published on June 25th, 2020. See the published version at https://doi.org/10.1186/s12903-020-01117-3.

## Abstract

Background: Mechanical plaque removal has been commonly accepted to be the basis for periodontitis treatment. The study aims to compare the effectiveness of ultrasonic subgingival scaling and subgingival hand scaling at different initial pocket probing depths in periodontitis treatment. Methods: Public databases were searched. Weighted mean pocket probing depths and clinical attachment loss reduction differences estimated by random effects model. Results: Ten randomized controlled trials were included out of 1,434 identified. Selected outcomes were pocket probing depth and clinical attachment loss. Initial pocket probing depth and follow-up periods formed subgroups. For 3-month follow-up: (1) too few shallow initial pocket studies available; (2) medium depth studies were unmergeable; (3) deep studies were adequate. No statistical differences between pocket probing depth nor clinical attachment loss reduction between ultrasound and hand groups. For 6-month follow-up: (1) too few shallow initial pocket probing depth studies for analysis; (2) medium initial pocket probing depth studies favored hand scaling. No statistical differences observed in clinical attachment loss reduction between the two approaches; (3) deep initial pocket probing depth studies showed hand scaling superior by both measures. Conclusion: When initial pocket probing depths were ≥4mm, pocket probing depth results, clinical attachment loss reduction, and other outcomes indicated subgingival hand scaling was superior. When operation duration and comfort were considered, ultrasonic debridement was.


## Background

Periodontitis is characterized by gingivitis and periodontal tissue destruction resulting in alveolar bone and tooth loss [1]. The 2010 Global Burden of Diseases Study reports that periodontitis is the sixth most common disease with a standardized prevalence of 11.2%. It is the primary cause of tooth loss [2].It negatively effects oral health, nutrition, self-confidence, and overall health. It associates with various systemic chronic inflammatory diseases such as angiocardiopathy and diabetes. Periodontitis is a primary public health problem [3].

In periodontitis, gum margin biofilm aggregates trigger immune responses. This tends to destroy surrounding soft tissue and absorb alveolar bone. These are important factors in periodontitis development [3]. Periodontal treatment is intended to control infection, and remove plaque, dental calculus, and endotoxins [4]. Hand instrument scaling and root planing (SRP) and ultrasonic debridement (UD) are primary techniques. Though UD is widely used for its greater efficiency, each technique has advantages and disadvantages. Currently there is no universal protocol for selecting one technique over another. Some studies found UD left more endotoxin and bacteria than SRP [5]. SRP requires greater operator experience and may lead to excessive cementum shaving and pulp damage [6]. Studies reported different surface roughness after UD and SRP. Some found greater post-UD surface roughness than post-SRP [7]. Others returned few differences [8, 9]. Root surface smoothness does not always bring improvement. Some suggested there were no relationships between smoothness and prognosis which would mean that removing infected tissue and preventing reinfection are keys to healing [10]. Some in-vitro studies showed a relationship between rougher surfaces and stronger fibroblast adhesion [11]. When root surfaces are smooth, cell membrane integrin expression and fibronectin activation are reduced. Tissue regeneration is depressed [12]. Roughness can relate to bacterial adhesion [10]. One study found that roughness increases wettability and affects plaque formation [13]. Others reported it did not [11]. Further research is needed.

Most in-vivo studies did not segregate by initial pocket probing depths (PPD) when comparing UD and SRP, but different initial PPD may greatly influence instrument selection. Beuchat found that when initial PPD < 6 mm, UD and SRP efficiencies were similar and when initial PPD > 7 mm, post-UD adhesion levels improved more and gingival recession (GR) was lower compared to SRP. These different results suggest that prior studies did not consider SRP and UD differences by different initial PPD [14].

Subjects in this study were grouped by initial PPD to obtain a more thorough understanding of different UD and SRP outcomes. It evaluated effects of the two methods to provide new evidence for clinical instrument selection and future study.

Acronyms used herein appear in Table S1.

## Methods

This meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). A statement has been registered at the International Prospective Register of Systematic Reviews (Number CRD42019125067).

# Research question

The focused question was developed in accordance with recognized Patient, Intervention, Comparison, and Outcome (PICO) format: "How does UD efficiency compare to SRP in periodontitis treatment at different initial pocket probing depths?”

# Selection Criteria

Study type:

Only hand- or UD-treated periodontitis patients in a completely randomized controlled trial (RCT) were included. Subjects were classified clinically by groupin initial pocket probing depth (PPD) into: (1) shallow: PPD ≤4mm; (2) medium: 4mm< PPD ≤6mm; or, (3) deep: PPD >6mm. Studies had to be in-vivo and compare UD with SRP for inclusion. A group could not be simultaneously included in different PPD categories. Root bifurcations were not considered in the selection process.

Studies meeting the following conditions were excluded: (1) follow-up in less than 3 months; (2) treatment during follow-up. Cluster trials not included. Studies with primary or secondary outcomes were included.

Participants:

Adults (age ≥18) diagnosed with periodontitis unaccompanied by any other oral or systemic disease and not taking antibiotics.

Intervention:

Meta-analysis sought to eliminate bias caused by different initial PPD to compare UD and SRP. There are several ultrasonic device makers. A maker may produce more than one model. All such devices share the same mechanism. Manual instruments operate on a different theory. No distinctions were made between UD makes or models. A Gracey scraper was chosen as the SRP instrument.

Outcomes:

A study may have primary and secondary indicators. Each indicator was processed differently. Not all outcomes were consistent with the criteria. The outcomes included appear in tables. (Table 1 and 2).

(1) Primary outcomes:

PPD and clinical attachment loss (CAL) were the primary outcomes to compare different subgroup outcomes.

(2) Secondary outcomes:

Bleeding on probing (BOP), GR, and post-scaling residual dental calculus were used as measures. These indicators are of interest. Data about them could not be extracted for meta-analysis due to the limited number of studies, their different measurements, and definitions. They were analyzed by comparing each study's results.

## Search strategy

PubMed, Cochrane Central Register of Controlled Trials, EMBASE, Medline, and ClinicalTrials.gov were searched until January, 2019 for relevant studies. The search was performed using a combination of controlled vocabulary and key words (Table S2). No language or time restrictions were imposed

Potentially eligible studies were considered for review irrespective of primary outcomes or language. A manual search using reference lists of related articles was performed.

## Data Collection and Analyses

(1) Study selection and quality assessment.

Three review authors (Zhang, Hu, and Zhu) independently searched and included eligible studies. The quality of each study was reviewed and evaluated and relevant data extracted. When there was a disagreement whether to include or not, a discussion including consulting corresponding author (Chen and Li) was held and an agreement reached on inclusion or exclusion.

A study's methodological quality was assessed using the original publication. Trial quality was evaluated using Cochrane review bias assessment risk criteria [15].

This included random sequence generation (selection bias), allocation concealment (selection bias), blinding of participants and personnel blinding (performance bias), outcome assessment blinding (detection bias), incomplete outcome data (attrition bias), selective reporting (reporting bias) and other biases. Possible ratings were ranked by risk: low (L); high (H); uncertain (U).

(2) Statistical analyses

When appropriate, data extracted was combined for meta-analysis using Review Manager 5.3. Effect size was estimated and reported as the mean difference (MD) for continuous variables with a 95% confidence interval (CI). Weight was calculated in individual studies based on the inverse of

variance. This study used a random-effects model for analyses due to expected heterogeneity of the studies selected. Study statistical homogeneity was assessed using a Cochran test and by examining the observed variances in effect sizes and residual variance. $I^2$ was calculated to quantify heterogeneity. $I^2$ >50% was considered significant [15]. No statistical corrections were used to adjust for multiple analyses.

According to Cochrane reviews [15], in meta-analysis, studies with baseline changes as outcomes could be combined with those with final measurements as outcomes. In randomized trials, differences in mean values obtained from baseline changes were usually analyzed on the basis of final measurements and obtained the same effects. In this meta-analysis, baseline changes and final measurements from different studies were combined.

A reason for disagreement among previous studies was that PPD influence had not been eliminated. The instant study established three subgroups based upon initial pocket depth: shallow; medium; and deep, to control for initial PPD effects.

If a study had two initial PPD groups that could be included in one subgroup, data was combined to conform to the depth classification, using the formulas in Table S3 [15].

## Results

# Study selection

There were 1,434 studies searched. References in selected papers were searched and no additional studies were located. After reading full the texts, ten studies were selected for qualitative synthesis. Process selection appears in Figure 1.

There were 495 duplicates in the 1,434 studies. There were 875 studies ruled out after reading titles and abstracts. Another 43 studies were ruled out after reading the full text. There were 11 unavailable or awaiting classification. Finally, 10 studies were included.

# Study characteristics

All research included were RCTs. Follow up periods were 3 and 6 months. Characteristics of articles selected for primary outcomes appear in Table 1. Characteristics of articles selected for secondary outcomes appear in Table 2. Reasons for study exclusion appear in Table S4.

Limited information of 11 studies could be obtained from the publication. Inclusion, or exclusion could not be decided because of unobtainable full texts and unknown specific conditions. These appear in Table S5.

# Quality and risk of bias assessment

Bias analysis results for the studies appear in Figures S1 and S2. Most studies do not have high bias risks. Funnel plots could not be done due to limited number of studies (<10).

# Meta-analysis Results

The follow-up period lengths of the studies varied. Most were 3 and 6 months. This allowed for grouping into 3- and 6-months and reduced heterogeneity.

**Outcome 1：PPD**

(1) 3 months:

a) Initial PPD ≤4mm

Only one met the criteria, which reported no statistical differences between UD and SRP[16].

b) Initial PPD >4mm

When initial PPD was medium, differences between hand and UD were statistically significant (Fig. 2A). PPD reduction after SRP was greater than for UD (MD 0.14，95% CI [0.02, 0.26], P = 0.02). Heterogeneity was great ($Tau^2$ = 0.01; $Chi^2$ = 28.94, df = 3 (P < 0.00001); $I^2$ = 90%).

When initial PPD was deep, heterogeneity was acceptable ($Tau^2$ = 0.01; $Chi^2$ = 4.24, df = 3 (P = 0.24); $I^2$ = 29%). PPD reduction after the two treatments were not statistically significant (MD 0.13, 95%CI [−0.02, 0.28], P = 0.09).

(2) 6 months:

a) Initial PPD ≤4mm

Two articles [16, 17] met the criteria as they used baseline changes as outcomes and one baseline changes value of 0. A meta-analysis could not be done using the two studies. They reported no statistical differences between UD and SRP.

b) Initial PPD >4mm

When initial PPD was medium, differences between SRP and UD were not statistically significant (MD 0.19, 95%CI [0.11, 0.27], P = 0.22). Heterogeneity was large ($Tau^2$ = 0.02; $Chi^2$ = 25.89, df = 3 (P < 0.0001); $I^2$ = 88%). (Fig. 2B)

When initial PPD was deep, heterogeneity rose slightly ($Tau^2$ = 0.08; $Chi^2$ = 8.74, df = 3 (P = 0.03); $I^2$ = 66%). PPD reduction after SRP was greater than UD with a statistically significant difference (MD 0.50, 95%CI [0.10, 0.89], P = 0.01).

**Outcome 2：CAL**

(1) 3 months:

a) Initial PPD ≤4mm

Only one met the criteria, reporting no statistically significant difference between the two methods [16].

b) Initial PPD >4mm

When initial PPD was medium, differences between SRP and UD were not statistically significant (MD −0.08，95%CI [−0.18, 0.03]，P = 0.14). Heterogeneity was great ($Tau^2$ = 0.01; $Chi^2$ = 10.92, df = 3 (P = 0.01); $I^2$ = 73%). (Fig. 2C)

When initial PPD was deep, difference between SRP and UD was not statistically significant (MD −0.06, 95%CI [−0.58, 0.46], P = 0.81). Heterogeneity was also high ($Tau^2$ = 0.16; $Chi^2$ = 23.28, df = 3 (P < 0.0001); $I^2$ = 87%).

(2) 6 months

a) Initial PPD ≤4mm

The heterogeneity of the two studies was too large ($Tau^2$ = 0.10; $Chi^2$ = 10.55, df = 1 (P = 0.001); $I^2$ = 91%) for a meta-analysis to be performed. They both indicated no statistically significant differences between ultrasonic and SRP [16, 17]. (Fig. 2D)

b) Initial PPD >4mm

No statistically significant differences were found between the ultrasonic and SRP when initial PPD was medium (MD −0.06, 95%CI [−0.17, 0.06], P = 0.33). Heterogeneity was slightly greater ($Tau^2$ = 0.01; $Chi^2$ = 6.29, df = 3 (P = 0.10); $I^2$ = 52%). (Fig. 2E)

At deep pocket depths, differences between the two were not statistically significant (MD 0.28, 95%CI [−0.20, 0.77], P = 0.26). Heterogeneity was large ($Tau^2$ = 0.15; $Chi^2$ = 10.37, df = 3 (P = 0.02); $I^2$ = 71%).

# Secondary outcome measures

(1) *GR*：Sculean et al. [18] indicated no statistical differences studying single or multiply-root teeth between SRP and UD at 6-months when initial PPD was deep. Kargas et al. [19] noted that, at medium depths, there were no statistical differences between ultrasonic and SRP at either 3 or 6-months.

(2) *BOP:* Christgau et al. [17] found that at 6-months, SRP showed greater BOP reduction for initial deep pocket compared to ultrasound.

(3) *Residual dental calculus:* Schwarz et al. [20] indicate that for single-root teeth at deep initial depth, UD was superior to SRP in removing subgingival dental calculus. Yukna et al. [21] found no statistical differences in residual dental calculus rates between UD and SRP with initial PPD in 5–6mm/7–8mm/ > 9mm. Gellin et al. [22] found no statistical differences in dental calculus clearance rates between the two when initial PPD was 0–3mm; 4–5mm; or, 6–12mm. When SRP was combined with UD, the effect was superior to either UD or SRP individually.

# Sensitivity analysis

**Outcome: PPD**

At 3-months, at medium depths, heterogeneity was great ($I^2$ = 90%). After sensitivity analysis, four studies were found highly heterogeneous to one another and was unsuitable for meta-analysis. After a bias analysis, the heterogeneity source was thought to be: (1) small number of studies; (2) the fact that tissue healing takes time and early probes disrupted attachment gains. At 3-months, PPD and CAL reductions were unstable, causing large heterogeneity.

At medium depth, 6-months, Kargas et al. [19] found significant heterogeneity. When excluded, heterogeneity decreased to 0% ($Tau^2$ = 0.00; $Chi^2$ = 0.02, df = 2 (P = 0.99); $I^2$ = 0%). The results showed statistically significant differences between hand and ultrasound groups. PPD reduction after SRP was greater than UD (MD 0.19,95%CI [0.11, 0.27], P<0.00001). Compared with the other three studies, only non-smokers were included and might be the reason for heterogeneity.

When initial PPD was deep at 6 months, D'Ercole [23].was a major derivation of heterogeneity ($Tau^2$ = 0.03; $Chi^2$ = 3.86, df = 2 (P = 0.15); $I^2$ = 48%) After exclusion, heterogeneity decreased to 48% (Fig. 3A).

**Outcome：CAL**

When was initial PPD was medium, at 3-months follow-up, results were similar to PPD reduction with high heterogeneity ($Tau^2$ = 0.01; $Chi^2$ = 10.92, df = 3 (P = 0.01); $I^2$ = 73%). According to a sensitivity analysis, four papers were highly heterogeneous with each other, making them unsuitable for meta-analysis (Fig. 3B). The same argument applies to a 3-month follow-up when initial PPD was medium: (1) too few studies; (2) tissue healing took time and early intervening probing may damage attachment gain. When the follow-up period was only 3 months, CAL were unstable which caused great heterogeneity.

Heterogeneity was also large in the following groups: 1) deep pocket, at 3-months follow-up; 2) medium and deep pockets, at 6-months follow-up [16]. After excluding this study, heterogeneity decreased from: 87%; 52%; and 71%, to 24%; 0%; and, 0%. This study's heterogeneity was quite big and should be excluded. After exclusion, at a 6-month follow-up, after UD, CAL reduction was more than SRP and were statistically significant different. (MD 0.58, 95%CI [0.27, 0.89], P = 0.0002) (Fig. 3C).

## Discussion

In the same paper, PPD and CAL heterogeneity in the studies was much greater at 3-months than at 6-months. The effect was quite apparent at medium PPD, 3-months. Deep PPD heterogeneity at either 3-months or 6-months was acceptable. This suggests that deep pocket heterogeneity has no relationship with time. The reason may be that the tissue took time to heal. In deep pockets, tissue contacted and attached to the bone better, resulting in shorter healing time and more stablility within 3 months. At medium pocket depths, tissue does not contact bone as readily as at deeper pockets, so healing time is longer. Probing too early in healing process may damage tissue and influence attachment gain and lead to unstable results.

Sensitivity analysis suggests that two few articles (1–2) met the requirement of shallow initial PPD. This meant that no reliable conclusions could be reached and more studies are required. PPD results were not reliable for medium pocket depths at the 3-month follow-up whose heterogeneity of four included articles was quite large and requires more studies to reach reliable conclusions. CAL medium pocket depths at a 3-month follow-up was similar. Post analysis: 1) medium depth [19] and deep depth [23] at 6-month follow-up for PPD, 2) deep pocket at 3-month follow-up, medium, and deep pocket at 6-months follow-up for CAL [16] were excluded.

After excluding a major source of heterogeneity, the deep initial PPD at 3-month follow-up and all data from the 6-month follow-up were analyzed and following results were returned:

A. deep pocket at 3-month follow-up:

PPD and CAL reductions showed no differences between ultrasound and hand groups.

B. 6-month follow-up:

a) for shallow initial PPD, there were no differences between hand and UD;

b) at medium initial PPD, PPD reduction showed SRP was better. CAL reduction showed no differences between ultrasound and hand groups;

c) at deep initial PPD, PPD and CAL indicated SRP was superior.

The number of roots, either single or multiple, had little effect on either hand or ultrasound at medium or deep PPD in terms of GR [18, 19].

BOP results from a study [17] showed superior BOP reduction at deep pocket depths with SRP than with ultrasound. Residual calculus provided different results. Two studies [21, 22] indicated that, regardless of depth, there were no statistical differences in calculus clearance rates between

ultrasound and hand treatment. Schwarz [20] indicated when PPD was deep, for a single-root tooth, ultrasonic dental calculus removal was more efficient than SRP.

There were others interesting results in various indicators.

Studies of bacteria populations returned complex results. In terms of bacterial reductions, some people indicated no differences between hand and ultrasound [17, 19], while other study [24] found SRP to be better. As for *Treponema denticola,* Ioannou [16] found SRP to be better when PPD ≥4mm, while Derdilopoulou [25] found ultrasonic treatments is. But Petelin [26] indicated that both have advantage in bacteria reduction and Breininger [27] found SRP somewhat more prone to leave apical, or calculus-associated, plaque.

When measuring cementum thickness, periodontal membrane cells and fibroblasts, Bozbay [28] found that UD retained more cementum. Schwarz [29] found periodontal membrane cells /mm² treated by ultrasound was significantly higher. SPR was similar to UD concerning fibroblast morphology in Foroutan [30]. When measuring inflammation, Malali [24] indicated white blood cell count decreased more after SRP but Torfason [31] found gingival crevicular fluid change was similar after SRP and UD.

Some researchers [10, 32] found root treatment with either SRP or UD, produced similar levels of roughness. But some researchers found root roughness [33] and morphology [28, 34] after SRP was higher than ultrasonic. Mittal [35] added less damage of root after UD.

Clinical operations, operation time, patient preferences, postoperative adverse reactions, operator sensitivity and other aspects warrant consideration. Ryan [36] discussed operator tactile sensitivity and found UD is better. Other researchers [4, 17, 18, 21, 28, 31, 37, 38] argue that ultrasound is less time-consuming. Stewart [39] found ultrasonic methods are faster in mandibular quadrants but there were no differences in maxillary quadrants. However, Graetz [40] found ultrasound took more time. Some [19, 25, 39, 41] found more patients preferred ultrasound. And some [17, 37] found hand scaling resulted in more serious post-operation adverse hypersensitiviy reactions.

According to the newly-released 2018 periodontitis classifications, there are some disputed understandings:

1. the differing economic and health care developments between developed and developing countries different influences on periodontitis [42, 43].Primary CAL in developing countries was three times of developed countries[43]. Only one study [24] involved a developing country (Turkey). Whether the conclusions reached in this paper apply to developing countries is unknown.
2. Smoking is confirmed as affecting progress of periodontitis and was considered in the new classification [42]. Most of the included studies chose patients according to the 1999 classification and did not consider the impact of smoking. This may cause heterogeneity.

## Summary:

**1. Significance to clinical practice**

(1) It may be premature to probe within 3 months after therapy. It may lessen attachment gain, slow or interrupt recovery and lead to inaccurate measurements. Only 6-month follow-up results are relied upon by the instant study to reach following conclusions:

a) When initial PPD was shallow, no conclusions were drawn due to the limited number of studies.

b) When initial PPD was medium, PPD reductions proved SRP as superior. CAL and GR results showed no statistical differences. More studies are needed before any conclusion can be drawn.

c) When initial PPD was deep, SRP was superior in terms of PPD reduction, CAL and BOP. This conclusion also needs more study because of the limited number of studies.

(2) Considering operating time, patient preferences, adverse reactions, and operator sensitivity, UD was superior to SRP.

(3) In terms of residual dental calculus, bacteria changes, cementum thickness, periodontal adhesion, and root surface roughness, no conclusions could be drawn.

(4) The studies used are mainly from developed countries and conclusions may not be applicable to developing countries.

(5) UD were recognized to be superior when initial PPD was shallow; SRP was found superior when initial PPD >4mm.

Although UD is becoming increasingly popular, SRP is still irreplaceable.

**2. Significance to research**

(1) Inclusion and exclusion criteria could refer to the new classification to reduce bias;

(2) Studies should consider other indicators such as BOP, PI, and GI, bacterial changes, when comparing in different PPDs;

(3) More studies are needed in developing countries;

(4) Age should be considered;

(5) 12-month follow-ups are suggested to determine reliable results;

(6) Single and multiple root teeth should be measured separately;

(7) Follow-up treatment shouldn't be carried out after initial therapy;

(8) Further studies should enlarge sample sizes to improve credibility;

(9) Inclusion or exclusion criteria for smokers should be standardized.

## Conclusions

Results varied between SRP and UD on different initial PPD: (1) the limited number of studies of shallow initial PPDs allow for no conclusion; (2) when initial PPD was medium, PPD reduction proved SRP superior, but CAL and GR reduction showed no statistical differences; (3) when initial PPD was deep, PPD and CAL reductions suggest that SRP was superior to UD. Other factors such as operating time, patient comfort, adverse reactions, and operator operating sensitivity proved UD superior.

Suggestions: (1) when initial PPD is shallow, use UD; (2) when initial PPD is medium or deep, use ultrasonic and SRP together.

UD has become increasingly popular but cannot replace SRP.

## Declaration

1) Ethics approval and consent to participate ( not applicable for that section).

2) Consent for publication( not applicable for that section).

3) Availability of data and material: Data in the study is from studies in the PubMed, Cochrane Central Register of Controlled Trials, EMBASE, Medline, and ClinicalTrials.gov.

4) Competing interests: The authors declare that they have no competing interests.

5) Funding: This review was supported in part by the Natural Science Foundation of Hunan Province for Young Scientists, China (Grant No: 2019JJ50784 to Li Wenjie); the Young Teacher's Institutional grant from Xiangya School of Stomatology and Xiangya Stomatological Hospital, Central South University (Li Wenjie); and the National-level College Students' Innovative Entrepreneurial Training Plan Program of China (Grant No: S201910533045).

6) Authors' contributions:

7) Acknowledgements: The Authors wish to thank Stephen Laudig for his English language editing of this article.

## References

1.IL C, F VdW, C D, D H, L S, D P, P M, A L, E M, N D *et al: Primary prevention of periodontitis: managing gingivitis.* 2015, *42(*undefined):S71–76.

2.NJ K, E B, M D, B B, CJ M, research MWJJod: *Global burden of severe periodontitis in 1990–2010: a systematic review and meta-regression.* 2014, *93(*11):1045–1053.

3.IL C, P B, MG C, G C, MC C, F C, L N, P H, ML L, P L *et al: Interaction of lifestyle, behaviour or systemic diseases with dental caries and periodontal diseases: consensus report of group 2 of the joint EFP/ORCA workshop on the boundaries between caries and periodontal diseases.* 2017, *44(*undefined):S39-S51.

4.Badersten A, Nilveus R, Egelberg J: *Effect of nonsurgical periodontal therapy I: moderately advanced periodontitis. Journal of clinical periodontology* 1981, *8(*1).

5.Yaghini J, Naghsh N, Attaei E, Birang R, Birang E: *Root Surface Roughness After Scaling and Root Planing with Er:YAG Laser Compared to Hand and Ultrasonic Instruments by Profilometry. Journal of dentistry (Tehran, Iran)* 2015, *12(*12):899–905.

6.Kawashima H, Sato S, Kishida M, Ito K: *A comparison of root surface instrumentation using two piezoelectric ultrasonic scalers and a hand scaler in vivo. Journal of periodontal research* 2007, *42(*1):90–95.

7.Folwaczny M, Merkel U, Mehl A, Hickel R: *Influence of parameters on root surface roughness following treatment with a magnetostrictive ultrasonic scaler: an in vitro study. Journal of periodontology* 2004, *75(*9):1221-1226.

8.M K, S S, research IKJJop: *Effects of a new ultrasonic scaler on fibroblast attachment to root surfaces: a scanning electron microscopy analysis.* 2004, *39(*2):111–119.

9.Singh S, Uppoor A, Nayak D: *A comparative evaluation of the efficacy of manual, magnetostrictive and piezoelectric ultrasonic instruments - an in vitro profilometric and SEM study. Journal of Applied Oral Science* 2012, *20(*1):21–26.

10.Rosales-Leal JI, Flores AB, Contreras T, Bravo M, Cabrerizo-Vilchez MA, Mesa F: *Effect of root planing on surface topography: an in-vivo randomized experimental trial. Journal of periodontal research* 2015, *50(*2):205-210.

11.S E, P B, S F, A L, investigations SAJCo: *In vitro evaluation of surface roughness, adhesion of periodontal ligament fibroblasts, and Streptococcus gordonii following root instrumentation with Gracey curettes and subsequent polishing with diamond-coated curettes.* 2013, *17(*2):397–404.

12.SJ D, Y I, L Y, G V, X L, A DTJTeP: *Apatite microtopographies instruct signaling tapestries for progenitor-driven new attachment of teeth.* 2011, *17(*null):279–290.

13.M Q, M M, HJ B, AH W, PL D, periodontology vSDJJoc: *The influence of surface free energy and surface roughness on early plaque formation. An in vivo study in man.* 1990, *17(*3):138–144.

14.Beuchat M, Busslinger A, Schmidlin PR, Michel B, Lehmann B, Lutz F: *Clinical comparison of the effectiveness of novel sonic instruments and curettes for periodontal debridement after 2 months. Journal of clinical periodontology* 2001, *28(*12):1145–1150.

15.JPT H: *Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [updated March 2011].* In. Edited by S G: The Cochrane Collaboration; 2011.

16.Ioannou I, Dimitriadis N, Papadimitriou K, Sakellari D, Vouros I, Konstantinidis A: *Hand instrumentation versus ultrasonic debridement in the treatment of chronic periodontitis: a randomized clinical and microbiological trial. Journal of clinical periodontology* 2009, *36(*2):132–141.

17.Christgau M, Männer T, Bauer S, Hiller KA, Schmalz G: *Periodontal healing after non-surgical therapy with a modified sonic scaler: A controlled clinical trial. Journal of Clinical Periodontology* 2006, *33(*10):749–758.

18.Sculean A, Schwarz F, Berakdar M, Romanos GE, Brecx M, Willershausen B, Becker J: *Non-surgical periodontal treatment with a new ultrasonic device (Vector-ultrasonic system) or hand instruments. Journal of clinical periodontology* 2004, *31(*6):428–433.

19.Kargas K, Tsalikis L, Sakellari D, Menexes G, Konstantinidis A: *Pilot study on the clinical and microbiological effect of subgingival glycine powder air polishing using a cannula-like jet. International journal of dental hygiene* 2015, *13(*3):161-169.

20.Schwarz F, Bieling K, Venghaus S, Sculean A, Jepsen S, Becker J: *Influence of fluorescence-controlled Er:YAG laser radiation, the Vector system and hand instruments on periodontally diseased root surfaces in vivo. Journal of clinical periodontology* 2006, *33(*3):200–208.

21.Yukna RA, Scott JB, Aichelmann-Reidy ME, LeBlanc DM, Mayer ET: *Clinical evaluation of the speed and effectiveness of subgingival calculus removal on single-rooted teeth with diamond-coated ultrasonic tips. Journal of periodontology* 1997, *68(*5):436-442.

22.Gellin RG, Miller MC, Javed T, Engler WO, Mishkin DJ: *The effectiveness of the Titan-S sonic scaler versus curettes in the removal of subgingival calculus. A human surgical evaluation. Journal of periodontology* 1986, *57(*11):672–680.

23.D'Ercole S, Piccolomini R, Capaldo G, Catamo G, Perinetti G, Guida L: *Effectiveness of ultrasonic instruments in the therapy of severe periodontitis: a comparative clinical-microbiological assessment with curettes. The new microbiologica* 2006, *29(*2):101–110.

24.Malali E, Kadir T, Noyan U: *Er:YAG lasers versus ultrasonic and hand instruments in periodontal therapy: clinical parameters, intracrevicular micro-organism and leukocyte counts. Photomedicine and laser surgery* 2012, *30(*9):543–550.

25.Derdilopoulou FV, Nonhoff J, Neumann K, Kielbassa AM: *Microbiological findings after periodontal therapy using curettes, Er: YAG laser, sonic, and ultrasonic scalers. Journal of clinical periodontology* 2007, *34(7*):588-598.

26.Petelin M, Perkič K, Seme K, Gašpirc B: *Effect of repeated adjunctive antimicrobial photodynamic therapy on subgingival periodontal pathogens in the treatment of chronic periodontitis. Lasers in medical science* 2015, *30(*6):1647-1656.

27.Breininger DR, O'Leary TJ, Blumenshine RV: *Comparative effectiveness of ultrasonic and hand scaling for the removal of subgingival plaque and calculus. Journal of periodontology* 1987, *58(*1):9–18.

28.Bozbay E, Dominici F, Gokbuget AY, Cintan S, Guida L, Aydin MS, Mariotti A, Pilloni A: *Preservation of root cementum: a comparative evaluation of power-driven versus hand instruments. International journal of dental hygiene* 2018, *16(*2):202–209.

29.Schwarz F, Aoki A, Sculean A, Georg T, Scherbaum W, Becker J: *In vivo effects of an Er:YAG laser, an ultrasonic system and scaling and root planing on the biocompatibility of periodontally diseased root surfaces in cultures of human PDL fibroblasts. Lasers in surgery and medicine* 2003, *33(*2):140–147.

30.Foroutan T, Amid R, Karimi MR: *Comparison of Manual Tools, Ultrasonic and Erbium-Doped Yttrium Aluminum Garnet (Er:YAG) Laser on the Debridement Effect of the Surface of the Root of Teeth Suffering from Periodontitis. Journal of lasers in medical sciences* 2013, *4(*4):199–205.

31.Torfason T, Kiger R, Selvig KA, Egelberg J: *Clinical improvement of gingival conditions following ultrasonic versus hand instrumentation of periodontal pockets. Journal of clinical periodontology* 1979, *6(*3):165–176.

32.Amid R, Kadkhodazadeh M, Fekrazad R, Hajizadeh F, Ghafoori A: *Comparison of the effect of hand instruments, an ultrasonic scaler, and an erbium-doped yttrium aluminium garnet laser on root surface roughness of teeth with periodontitis: a profilometer study. Journal of periodontal & implant science* 2013, *43(*2):101–105.

33.Santos FA, Pochapski MT, Leal PC, Gimenes-Sakima PP, Marcantonio Jr E: *Comparative study on the effect of ultrasonic instruments on the root surface in vivo. Clinical Oral Investigations* 2008, *12(*2):143–150.

34.Maritato M, Orazi L, Laurito D, Formisano G, Serra E, Lollobrigida M, Molinari A, De Biase A: *Root surface alterations following manual and mechanical scaling: A comparative study. International journal of dental hygiene* 2018, *16(*4):553–558.

35.Mittal A, Nichani AS, Venugopal R, Rajani V: *The effect of various ultrasonic and hand instruments on the root surfaces of human single rooted teeth: A Planimetric and Profilometric study. Journal of Indian Society of Periodontology* 2014, *18(*6):710–717.

36.Ryan DL, Darby M, Bauman D, Tolle SL, Naik D: *Effects of ultrasonic scaling and hand-activated scaling on tactile sensitivity in dental hygiene students. Journal of dental hygiene: JDH* 2005, *79(*1):9.

37.Wennström JL, Tomasi C, Bertelle A, Dellasega E: *Full-mouth ultrasonic debridement versus quadrant scaling and root planing as an initial approach in the treatment of chronic periodontitis. Journal of Clinical Periodontology* 2005, *32(*8):851–859.

38.Badersten A, Nilveus R, Egelberg J: *Effect of nonsurgical periodontal therapy II: severely advanced periodontitis. Journal of clinical periodontology* 1984, *11(*1).

39.Stewart JL, Prisko PR, Herlach AD: *Comparison of Ultrasonic and hand instruments for the removal of calculus. Journal of the american dental association (1939)* 1967, *75(*1).

40.Graetz C, Schwendicke F, Plaumann A, Rauschenbach S, Springer C, Kahl M, Sälzer S, Dörfer CE: *Subgingival instrumenation to remove simulated plaque in vitro: influence of operators' experience and type of instrument. Clinical oral investigations* 2015, *19(*5):987-995.

41.Braun A, Krause F, Nolden R, Frentzen M: *Subjective intensity of pain during the treatment of periodontal lesions with the Vector-system. Journal of periodontal research* 2003, *38(*2):135–140.

42.Papapanou PN, Sanz M, Buduneli N, Dietrich T, Feres M, Fine DH, Flemmig TF, Garcia R, Giannobile WV, Graziani F *et al: Periodontitis: Consensus report of workgroup 2 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions. Journal of clinical periodontology* 2018, *45 Suppl 20:*S162-S170.

43.Needleman I, Garcia R, Gkranias N, Kirkwood KL, Kocher T, Iorio AD, Moreno F, Petrie A: *Mean annual attachment, bone level, and tooth loss: A systematic review. Journal of clinical periodontology* 2018, *45 Suppl 20:*S112-S129.

44.Dibart S, Capri D, Casavecchia P, Nunn M, Skobe Z: *Comparison of the effectiveness of scaling and root planing in vivo using hand vs rotary instruments. The International journal of periodontics & restorative dentistry* 2004, *24(*4):370–377.

45.Van Dijk LJ, Lie MA, Van den Heuvel ER, Van der Weijden GA: *Adult periodontitis treated with a new device for subgingival lavage-a randomized controlled clinical trial using a split-mouth design. International journal of dental hygiene* 2018, *16(*4):559–568.

46.Wang Y, Li W, Shi L, Zhang F, Zheng S: *Comparison of clinical parameters, microbiological effects and calprotectin counts in gingival crevicular fluid between Er: YAG laser and conventional periodontal therapies. Medicine (united states)* 2017, *96(*51) (no pagination).

47.Dukić W, Bago I, Aurer A, Roguljić M: *Clinical effectiveness of diode laser therapy as an adjunct to non-surgical periodontal treatment: a randomized clinical study. Journal of periodontology* 2013, *84(*8):1111-1117.

48.Slot DE, Timmerman MF, Versteeg PA, van der Velden U, van der Weijden FA: *Adjunctive clinical effect of a water-cooled Nd: YAG laser in a periodontal maintenance care programme: a randomized controlled trial. Journal of clinical periodontology* 2012, *39(*12):1159-1165.

49.Biagini G, Checchi L, Miccoli MC, Vasi V, Castaldini C: *Root curettage and gingival repair in periodontitis. Journal of periodontology* 1988, *59(*2):124–129.

50.Oberholzer R, Rateitschak KH: *Root cleaning or root smoothing. An in vivo study. Journal of clinical periodontology* 1996, *23(*4):326-330.

51.Slot DE, Kranendonk AA, Van der Reijden WA, Van Winkelhoff AJ, Rosema NA, Schulein WH, Van der Velden U, Van der Weijden FA: *Adjunctive effect of a water-cooled Nd: YAG laser in the treatment of chronic periodontitis. Journal of clinical periodontology* 2011, *38(*5):470-478.

52.Romeo U, Palaia G, Botti R, Leone V, Rocca JP, Polimeni A: *Non-surgical periodontal therapy assisted by potassium-titanyl-phosphate laser: a pilot study. Lasers in medical science* 2010, *25(*6):891-899.

53.Yukna RA, Carr RL, Evans GH: *Histologic evaluation of an Nd: YAG laser-assisted new attachment procedure in humans. International journal of periodontics & restorative dentistry* 2007, *27(*6):577-587.

54.Feng XH, Lu RF, He L: *A short-term clinical evaluation of periodontal treatment with an Er: YAG laser for patients with chronic periodontitis: a split-mouth controlled study. Beijing da xue xue bao [Journal of Peking University Health sciences]* 2011, *43(*6):886-890.

55.Wu K-Y, Xu C-J, Chi Y-T, Sun X-J, Wang H-F: *Detection of Dickkopf–1 and alkaline phosphatase activity in gingival crevicular fluid from chronic periodontitis with Er:YAG laser as an adjunctive treatment. Shanghai kou qiang yi xue = Shanghai journal of stomatology* 2017, *26(*3):285–289.

56.Obeid PR, D'Hoore W, Bercy P: *Comparative clinical responses related to the use of various periodontal instrumentation. Journal of clinical periodontology* 2004, *31(*3):193–199.

57.Kishida M, Sato S, Ito K: *Comparison of the effects of various periodontal rotary instruments on surface characteristics of root surface. Journal of oral science* 2004, *46(*1):1–8.

58.Khosravi M, Bahrami ZS, Atabaki MS, Shokrgozar MA, Shokri F: *Comparative effectiveness of hand and ultrasonic instrumentations in root surface planing in vitro. Journal of clinical periodontology* 2004, *31(*3):160–165.

59.Gagnot G, Mora F, Poblete MG, Vachey E, Michel JF, Cathelineau G: *Comparative study of manual and ultrasonic instrumentation of cementum surfaces: influence of lateral pressure. The International journal of periodontics & restorative dentistry* 2004, *24(*2):137–145.

60.Croft LK, Nunn ME, Crawford LC, Holbrook TE, McGuire MK, Kerger MM, Zacek GA: *Patient preference for ultrasonic or hand instruments in periodontal maintenance. The International journal of periodontics & restorative dentistry* 2003, *23(*6):567–573.

61.Kocher T, Rosin M, Langenbeck N, Bernhardt O: *Subgingival polishing with a teflon-coated sonic scaler insert in comparison to conventional instruments as assessed on extracted teeth (II). Subgingival roughness. Journal of clinical periodontology* 2001, *28(*8).

62.Kocher T, Rühling A, Momsen H, Plagmann HC: *Effectiveness of subgingival instrumentation with power-driven instruments in the hands of experienced and inexperienced operators. A study on manikins. Journal of clinical periodontology* 1997, *24(*7):498–504.

63.Copulos TA, Low SB, Walker CB, Trebilcock YY, Hefti AF: *Comparative analysis between a modified ultrasonic tip and hand instruments on clinical parameters of periodontal disease. Journal of periodontology* 1993, *64(*8):694–700.

64.Kepic TJ, O'Leary TJ, Kafrawy AH: *Total calculus removal: an attainable objective? Journal of periodontology* 1990, *61(*1):16-20.

65.Garnick JJ, Dent J: *A scanning electron micrographical study of root surfaces and subgingival bacteria after hand and ultrasonic instrumentation. Journal of periodontology* 1989, *60(*8):441–447.

66.Hunter RK, O'Leary TJ, Kafrawy AH: *The effectiveness of hand versus ultrasonic instrumentation in open flap root planing. Journal of periodontology* 1984, *55(*12):697–703.

67.Thornton S, Garnick J: *Comparison of ultrasonic to hand instruments in the removal of subgingival plaque. Journal of periodontology* 1982, *53(*1):35–37.

68.Nishimine D, O'Leary TJ: *Hand instrumentation versus ultrasonics in the removal of endotoxins from root surfaces. Journal of periodontology* 1979, *50(*7):345–349.

69.D'Silva IV, Nayak RP, Cherian KM, Mulky MJ: *An evaluation of the root topography following periodontal instrumentation—a scanning electron microscopic study. Journal of periodontology* 1979, *50(*6):283–290.

70.Ewen SJ, Scopp IW, Witkin RT, Ortiz-Junceda M: *A comparative study of ultrasonic generators and hand instruments. Journal of periodontology* 1976, *47(*2):82–86.

71.Gutknecht N, Van Betteray C, Ozturan S, Vanweersch L, Franzen R: *Laser supported reduction of specific microorganisms in the periodontal pocket with the aid of an Er,Cr:YSGG laser: a pilot study. TheScientificWorldJournal* 2015, *2015:*450258.

72.Geng SF, Xu L, Ying P, Cao CF: *[Clinical evaluation of manual and ultrasonic subgingival scaling using image analysis]. Shanghai kou qiang yi xue = Shanghai journal of stomatology* 1992, *1(*2):73–76.

73.Kahl M, Haase E, Kocher T, Rühling A: *Clinical effects after subgingival polishing with a non-aggressive ultrasonic device in initial therapy. Journal of clinical periodontology* 2007, *34(*4):318-324.

74.Kocher T, Plagmann HC: *Root debridement of molars with furcation involvement using diamond-coated sonic scaler inserts during flap surgery—a pilot study. Journal of clinical periodontology* 1999, *26(*8):525–530.

75.Oosterwaal PJ, Matee MI, Mikx FH, van 't Hof MA, Renggli HH: *The effect of subgingival debridement with hand and ultrasonic instruments on the subgingival microflora. Journal of clinical periodontology* 1987, *14(*9):528–533.

76.Wright GL, Lee CQ, Anderson DM, Gettleman BH: *Debris forced through apical foramina by ultrasonic and hand instrumentation. General dentistry* 1993, *41 Spec No:*478–481.

77.Thomas K, Vandana KL, Reddy VR: *A clinical and SEM evaluation of the efficiency of sofscale gel and hand scaling and hand scaling alone. Indian journal of dental research: official publication of Indian Society for Dental Research* 2002, *13(*3–4):173–182.

78.Cross-Poline GN, Stach DJ, Newman SM: *Effects of curet and ultrasonics on root surfaces. American journal of dentistry* 1995, *8(*3):131–133.

79.Dragoo MR: *A clinical evaluation of hand and ultrasonic instruments on subgingival debridement. 1. With unmodified and modified ultrasonic inserts. The International journal of periodontics & restorative dentistry* 1992, *12(*4):310–323.

80.Laurell L, Pettersson B: *Periodontal healing after treatment with either the Titan-S sonic scaler or hand instruments. Swedish dental journal* 1988, *12(*5):187–192.

81.Lie T, Meyer K: *Calculus removal and loss of tooth substance in response to different periodontal instruments. A scanning electron microscope study. Journal of clinical periodontology* 1977, *4(*4):250–262.

82.Forabosco A, Spinato S, Grandi T, Prini M: *A comparative study between different techniques in non-surgical periodontal treatment. Minerva stomatologica* 2006, *55(*5):289–296.

83.Nonhoff J, Derdilopoulou F, Neumann K, Kielbassa AM: *A quadrant-design trial of four therapeutic modalities in chronic moderate periodontitis. Schweizer monatsschrift fur zahnmedizin = revue mensuelle suisse d'odonto-stomatologie = rivista mensile svizzera di odontologia e stomatologia* 2006, *116(*5):484-492.

84.Kuchumova ED, Stiuf IV: *Study of the influence of different instruments for removing dental deposits on tooth surface. Stomatologiia* 2006, *85(*6):27–30.

85.Diedrich P, Vahl J, Bomfleur W, Mutschelknauss R: *Scanning eletronmicroscopical studies of the root surface following the use of various hand and ultrasonic instruments]. Dtsch Zahnarztl Z* 1975, *30(*6):396–405.

86.Caffesse RG, Caride ER, Rezzano SM, Exposito N: *[Effect of manual and ultrasonic instrumentation on the radicular surface]. Revista da Associacao Paulista de Cirurgioes Dentistas* 1973, *27(*3):129–134.

## Tables

Table 1. Included studies characteristics (Primary outcome measures)

| Study | First Author, Year<br>Outcomes<br>Mean age (±SEM)<br>Female/Male<br>Country | PPD | Interventions | Follow Up | Inclusion criteria | Exclusion criteria | Smoker/Non-smokers ratio |
|---|---|---|---|---|---|---|---|
| Pilot study on the clinical and microbiological effect of subgingival glycine powder air polishing using a cannula-like jet | - (Kargas et al., 2015)<br>- PPD, CAL<br>- 52.50±9.54<br>- 12/15<br>- Greece | moderate pockets | ultrasonic instrumentation (Piezonâ, Instrument A, EMS, Nyon, Switzerland) hand instruments (Gracey curettes 3/4, 11/12, 13/14, Hu-Friedy, Chicago, IL, USA) | 6 Months | (a) Must have been previously diagnosed with generalized chronic periodontitis (according to American Academy of Periodontology) and successfully treated;<br>(b) Subsequently, entered the supportive treatment phase (SPT), with at least two non-bleeding residual pockets >4 mm in each quadrant;<br>(c) Have at least 20 natural teeth;<br>(d) Non-smoker;<br>(e) Could not taken an antibiotic, anti-inflammatory medication, corticosteroids or other immunosuppressive drugs during the previous 6 months;<br>(f) Pregnant or lactating women were also excluded from this study. | None | No smoker |
| Er:YAG lasers versus ultrasonic and hand instruments in periodontal therapy: clinical parameters, intracrevicular micro-organism and leukocyte counts | - (Malali et al., 2012)<br>- PPD CAL<br>- 48.83±7.23<br>- 11/19<br>- Turkey | 4-6mm, >7mm | a magnetostrictive ultrasonic scaler (Cavitron Bobcat Pro, Dentsply International Inc, USA) manual periodontal curettes (Gracey, SG # 5/6, 7/8, 11/12, 13/14, Mini Five Gracey SAS # 5/6, 11/12, Hu-Friedy Ins. Co., USA) | 3 Months | Patients with generalized periodontal breakdown and who had at least four single-rooted teeth, two moderately deep (probing depth [PD] of 4–6mm) and two deep pockets (PD≥ 7mm) that had no endodontic lesion and no crown, with mobility 0-2, and with bleeding on probing (BOP) were selected. | (a) Periodontal treatment within the last 6 months; (b) Any systemic disease that would influence the periodontal tissues; (c) Antibiotic used within last 6 months; (d) Pregnancy and smoking. | No smoker |
| Hand instrumentation versus ultrasonic debridement in the treatment of chronic periodontitis: a randomized clinical and microbiological trial | - (Ioannou et al., 2009)<br>- PPD, CAL<br>- SRP:49.62±2.07 UD 50.47±2.58<br>- SRP:50/50 UD:70.6/29.4<br>- Greece | <4mm, 4-6mm, >6mm | UD: (EMS Piezon®, EMS, Nyon, Switzerland) with A and P instruments (Swiss InstrumentsPM, EMS) under water irrigation SRP:Hu-Friedy Gracey Standard Curettes SG 3/4, 11/12, 13/14, After Five® Curettes SAS 3/4, 11/12, 13/14, Hu-Friedy. | 3 Months, 6 Months | (a) Adults between 18 and 70 years of age;<br>(b) Existence of a minimum of four sites with PPD 5 mm in at least two quadrants of each of the patients, demonstrating bleeding on probing;<br>(c) No periodontal treatment during the previous 6 months. | (a) Compromised medical condition; (b) Systemic antibiotics during treatment or for the last 3 months; (c) Ongoing drug therapy that might affect periodontal therapy; (d) Requirement for prophylactic antibiotic cover of the patient; (e) Use of chlorhexidine mouthwash or any other antimicrobial agent; (f) Pregnancy for female patients. | SRP: 50% of patients is smoker;<br>UD: 52.9% of patients is smoker. |
| Non-surgical periodontal treatment with | - (Sculean et al., 2004)<br>- PPD CAL<br>- 54 | 4-6mm, >6mm | VUS: Vector probe, (Durr Dental, Bietigheim- | 6 Months | (a) No treatment of periodontitis for the last 2 years; | None | Unclear |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| a new ultrasonic device (Vector™-ultrasonic system) or hand instruments a prospective, controlled clinical study | - 24/14(VUS:10/9;SRP:11/8) -Germany | | Bissingen,Germany) using straight and curved metal curettes and a polishing fluid (HA particles <10um) according to the instructions given by the manufacturer SRP:Hand instruments (Gracey Curettes, Hu-Friedy Co., Chicago, IL, USA). | | (b) No use of antibiotics for the 12 months prior to treatment; (c) No systemic diseases, and (d) Good level of oral hygiene. As criterion for a good level of oral hygiene a mean plaque index (PI) score <1 was chosen. | | |
| Periodontal healing after non-surgical therapy with a modified sonic scaler: A controlled clinical trial | - (Christgau et al., 2006) - PPD, CAL - 45.6±8.0 - 14/6 - Germany | <4mm, 4-6mm, >6mm | UD:the modified sonic scaler system SonicFlex 2003L (KaVo) SRP:Gracey-curettes #1/2, #7/8, #11/12, #13/14, HuFriedy, Chicago, IL, USA. | 6 Months, 1 Month(excluded) | All had generalized moderate to progressive chronic periodontitis, but were systemically healthy and had not received systemic antibiotics for at least 3 months before. Each patient had to show at least four teeth per quadrant with a PPD of at least 4 mm. | None | 14/6 |
| Full-mouth ultrasonic debridement versus quadrant scaling and root planing as an initial approach in the treatment of chronic periodontitis* | - (Wennström et al., 2005) - PPD CAL - 25-75 years old mean age 49.8 - 19/22 SRP11/10;UD8/12 - Italy, Sweden | 5-6mm, 7mm | UD:EMS Piezon Master 400 with A+PerioSlim tips, water coolant and power setting to 75%; EMS, Nyon, Switzerland SRP:LM-dental, Turku, Finland. | 3 Months, 6 Months | (a) Age 25–75 years; (b) A minimum of 18 teeth; (c) At least eight teeth must show probing pocket depths (PPD) of 5 mm and bleeding on probing (BOP). At least two of these teeth must have a PPD of 7 mm and at additional two teeth, the pockets must measure 6 mm; (e) Unremarkable general health according to medical history and clinical judgement; (f) Female patients must not be pregnant. | (a) Subgingival instrumentation within 12 months prior to the baseline examination; (b) The use of antibiotics within 3 months prior to the start of the study; (c) Compromised medical conditions requiring prophylactic antibiotic coverage; (d) Ongoing drug therapy that might affect the clinical signs and symptoms of periodontitis. | Italy: UD 4/11, SRP 4/10, Sweden: UD 7/10, SRP 6/11 |
| Effectiveness of ultrasonic instruments in the therapy of severe periodontitis: a comparative clinical-microbiological assessment with curettes | - (D'Ercole et al., 2006) - PPD CAL - 40.8 ±3.9 - 11/7 - Unclear | ≥6mm | UD:a power-driven mechanism(Vector® System) SRP: the type of manual instuments is unclear | 3 Months, 6 Months, 1 Month(excluded) | (a) Positive for diagnosis of mild-to-severe chronic periodontitis; (b) Good general health according to their medical history; (c) Negative for the use of any antibiotic or antiinflammatory drugs within the three months preceding the beginning of the study; (d) Negative for periodontal therapy within 1 year preceding the beginning of the study; (e) Experimental sites (test and control) localized in the interproximal position of two different teeth in the same subject (split-mouth design); | None | No-smoker |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | (f) Probing depth (PD) values equal to or more than 6 mm in the experimental sites; (g) Difference of PD in the experimental sites (test and control) not exceeding 2 mm; (h) Presence of at least ten teeth for each dental arch. Pregnant or nursing females were excluded from the study. |

SRP, scaling and root planing; UD, ultrasonic debridement; PPD, probing pocket depth; CAL, clinical attachment level.

All contents of the table are from the reference paper directly. Except for the serial number, there is no modification.

*: The data is from two study centers: Italy and Sweden.

Table 2. Included studies characteristics (Secondary outcome measures)

| Study | First Author, Year<br>Outcomes<br>Mean age (±SEM)<br>Female/Male<br>Country | PPD | Interventions | Follow Up | Inclusion criteria | Exclusion criteria | Smoker/Non-smokers ratio |
|---|---|---|---|---|---|---|---|
| Pilot study on the clinical and microbiological effect of subgingival glycine powder air polishing using a cannula-like jet | - (Kargas et al., 2015)<br>- GR<br>- 52.50±9.54<br>- 12/15<br>- Greece | Moderate pockets | Ultrasonic instrumentation (Piezonâ, Instrument A, EMS, Nyon, Switzerland)<br>Hand instruments (Gracey curettes 3/4, 11/12, 13/14, Hu-Friedy, Chicago, IL, USA) | 6 Months | (a) Must have been previously diagnosed with generalized chronic periodontitis (according to American Academy of Periodontology) and successfully treated;<br>(b) Subsequently, entered the supportive treatment phase (SPT), with at least two non-bleeding residual pockets >4 mm in each quadrant;<br>(c) Have at least 20 natural teeth;<br>(d) Non-smoker;<br>(e) Could not taken an antibiotic, anti-inflammatory medication, corticosteroids or other immunosuppressive drugs during the previous 6 months;<br>(f) Pregnant or lactating women were also excluded from this study. | None | No smoker |
| Clinical evaluation of the speed and effectiveness of subgingival calculus removal on single-rooted teeth with diamond-coated ultrasonic tips | - (Yukna et al., 1997)<br>- The mean percent of calculus remaining<br>- Unclear<br>- Unclear<br>- America | 5-6mm, 7-8mm | Hand curets, Plain ultrasonic | Extract the teeth after the treatment | Subjects had moderately deep probing depths (5 mm in depth), had not received scaling and root planing for at least 6 months prior to the study, and exhibited clinically and/or radiographically evident subgingival calculus on the study teeth. | None | Unclear |
| The effectiveness of the Titan-S sonic scaler versus curettes in the removal of subgingival calculus. A human surgical evaluation | - (Gellin et al., 1986)<br>- The percentage of surfaces with residual calculus<br>- Unclear<br>- Unclear<br>- America | <3mm, 4-5mm, 6-12mm | Ultrasonic instrument (Titan-S), Hand instrument (Gracey curette and the McCall's) | Extract the teeth after the treatment | Exhibit radiographie evidence of subgingival calculus or a clinically detectable ledge of subgingival calculus on at least one interproximal surface per quadrant, and have no systemic disease contraindicating periodontal therapy or the use of local anesthetics. | None | Unclear |
| Non-surgical periodontal treatment with a new ultrasonic device (Vector™-ultrasonic system) or hand instruments a prospective, controlled clinical study | - (Sculean et al., 2004)<br>- GR, BOP<br>- 54<br>- 24/14(VUS:10/9;SRP:11/8)<br>-Germany | 4-6mm, >6mm | UD: Vector probe,(Durr Dental, Bietigheim-Bissingen,Germany) using straight and curved metal curettes and a polishing fluid (HA particles <10um) according to the instructions given by the manufacturer SRP:Hand instruments (Gracey Curettes, Hu-Friedy Co., Chicago, IL, USA). | 6 Months | (a) No treatment of periodontitis for the last 2 years;<br>(b) No use of antibiotics for the 12 months prior to treatment;<br>(c) No systemic diseases;<br>(d) Good level of oral hygiene. As criterion for a good level of oral hygiene a mean | None | Unclear |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | plaque index (PI) score <1 was chosen. | | |
| Periodontal healing after non-surgical therapy with a modified sonic scaler: A controlled clinical trial | - (Christgau et al., 2006)<br>- BOP, GR<br>- 45.6±8.0<br>- 14/6<br>- Germany | <4mm, 4-6mm, >6mm | UD:the modified sonic scaler system SonicFlex 2003L (KaVo)<br>SRP:Gracey-curettes #1/2, #7/8, #11/12, #13/14, HuFriedy, Chicago, IL, USA. | 6 Months, 1 Month(excluded) | All had generalized moderate to progressive chronic periodontitis, but were systemically healthy and had not received systemic antibiotics for at least 3 months before. Each patient had to show at least four teeth per quadrant with a PPD of at least 4 mm. | None | 14/6 |
| Influence of fluorescence-controlled Er:YAG laser radiation, the Vector™ system and hand instruments on periodontally diseased root surfaces in vivo | - (Schwarz et al., 2006)<br>- The roughness of cementum surface<br>- 44.8<br>- 7/5<br>- Germany | >6mm | UD:ultrasonic system (Vector™,Dürr,Bietigheim-Bissingen,Germany) and a polishing fluid (hydroxylapatite particles <10 µm) was used according to the instructions given by the manufacturer(70% power setting). SRP: Gracey curets(Hu-Friedy Co., Chicago,IL,USA) | Extract the teeth after the treatment | (a) Probing pocket depths (>6 mm) on at least two aspects (mesio-buccal/mesio-lingual and disto-buccal/disto-lingual) as measured from the gingival margin to the bottom of the pocket;<br>(b) No signs of carious or artificial damage on the root surface;<br>(c) No periodontal root surface treatment within the last 12 months;<br>(d) No root fractures or anatomical abnormalities. | Patients suffering from systemic diseases were excluded from the study. | Unclear |

SRP, scaling and root planing; UD, ultrasonic debridement; GR, gingival recession; BOP, bleeding on probing.

## Figures

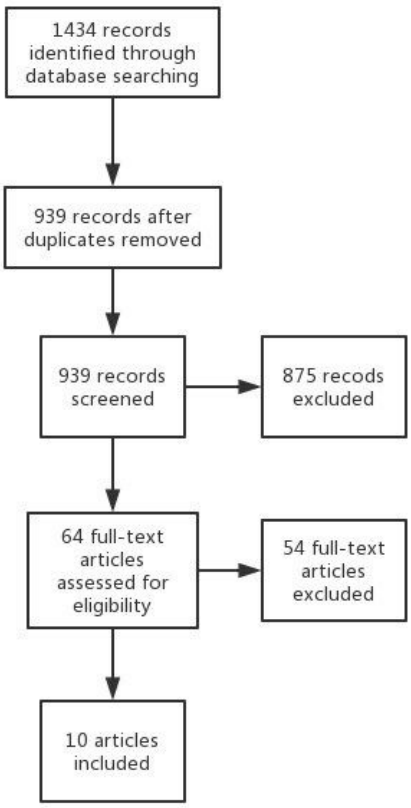
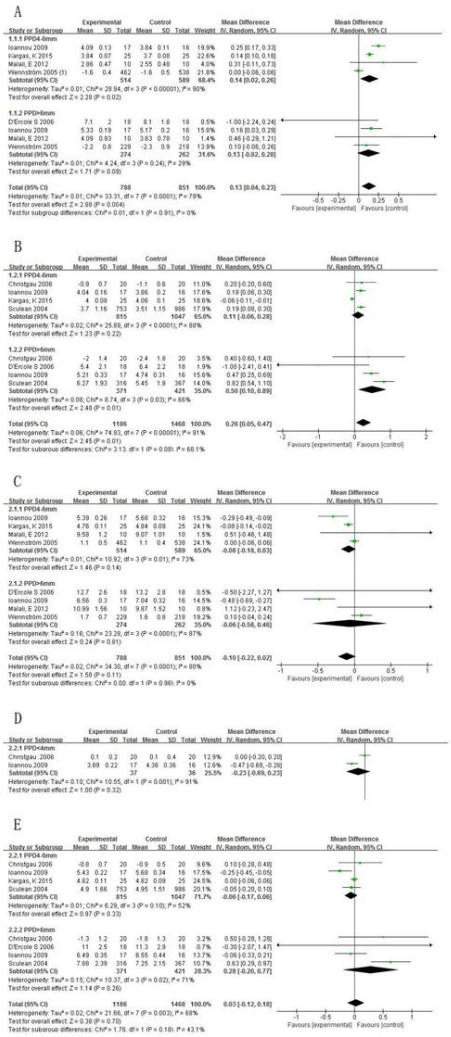



**Figure 1**

Selection process PRISMA flow chart




## Figure 2

Figure 2A. Forest plot comparing PPD at 3-months with hand versus UD of initial PPD>4mm in terms of the following: 1.1.1 PPD4-6mm; 1.1.2 PPD>6mm Figure 2B. Forest plot comparing PPD at 6-months with hand versus UD of initial PPD>4mm in terms of the following: 1.2.1 PPD4-6mm; 1.2.2 PPD>6mm Figure 2C. Forest plot comparing CAL at 3-months with hand versus UD of initial PPD>4mm in terms of the following: 2.1.1 PPD4-6mm; 2.1.2 PPD>6mm Figure 2D. Forest plot comparing CAL at 6-months with hand versus UD of initial PPD were shallow in terms of the following: 2.2.1 PPD≤4mm. Figure 2E. Forest plot comparing CAL at 6-months with hand versus UD of initial PPD>4mm in terms of the following: 2.2.1 PPD4-6mm; 2.2.2 PPD>6mm.

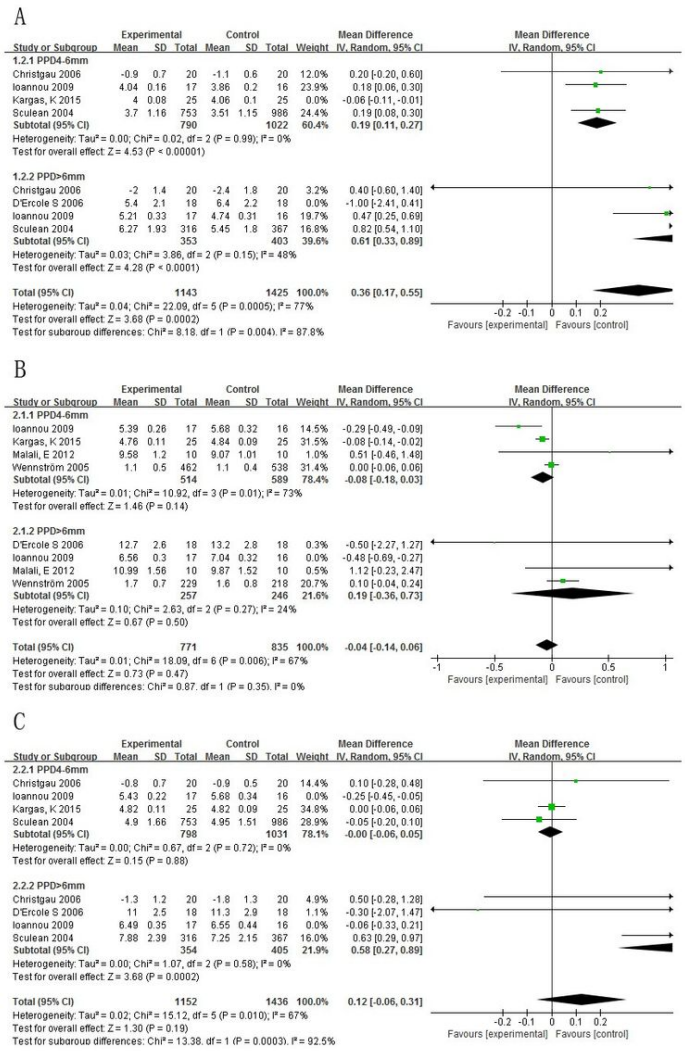



**Figure 3**

3A. Sensitivity analysis of PPD at 6-months in terms of the following: 1.2.1 PPD 4-6mm; 1.2.2 PPD >6mm. Figure 3B. Sensitivity analysis of CAL at 3-months in terms of the following: 2.1.1 PPD 4-6mm; 2.1.2 PPD >6mm. Figure 3C. Sensitivity analysis of CAL at 6-months in terms of the following: 2.2.1 PPD 4-6mm; 2.2.2 PPD >6mm.

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- supplement1.docx