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## Pocket elimination after osseous resective surgery: A systematic review and meta-analysis

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(Article begins on next page)



# UNIVERSITÀ DEGLI STUDI DI TORINO

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**Pocket elimination after osseous resective surgery: a systematic review and meta-analysis.**

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## **Abstract**

*Aim:* To systemically review the available evidence on the clinical performance of Osseous Resective Surgery (ORS) in the treatment of residual periodontal defects in terms of pocket elimination and biological costs in patients with chronic periodontitis.

*Materials and Methods:* Three databases (PubMed, EMBASE, and Cochrane) were searched up to January 2019. Clinical trials with a follow-up duration of at least 12 months after ORS with or without fibre retention technique were included. Quantitative synthesis was conducted with random-effect meta-analysis.

*Results:* Overall, 1765 studies were retrieved, of which 53 full-text articles were screened by two reviewers. Finally, a total of three RCTs were included in the meta-analysis. Random-effect meta-analysis showed a weighted mean percentage of pocket elimination (final PD  $\leq$  4 mm) at 12 months of 98.3% (95% CI: 96.8; 99.7) with  $I^2$  of 26%. The weighted mean amount of resected bone was 0.87 mm (95% CI: 0.49; 1.25) and the weighted mean increase in gingival recession was 2.13 mm (95% CI: 1.49; 2.78) at 12 months.

*Conclusions:* ORS represents an effective surgical approach for the elimination of residual periodontal pockets in the short- to medium-term. Additional randomized controlled clinical trials with data on pocket elimination are warranted.



## **Clinical relevance**

*Scientific rationale for the study:* This systematic review aimed to analyse the efficacy of ORS in terms of percentage of pocket elimination ( $PD \leq 4$  mm) in posterior sextants. It represents the main endpoint of successful periodontal treatment as suggestive of clinical stability and long-term tooth maintenance.

*Principal findings* The majority of studies in literature reported mean PD changes after ORS as outcome variable. PD reduction is related to baseline parameters and does not provide information on the risk of further disease progression.

*Practical implications:* The success of ORS should be estimated by assessing pocket elimination as clinical endpoint.

## **Introduction**

The definitive goal of periodontal treatment is to arrest clinical attachment loss progression and to prevent tooth loss. Several studies have demonstrated the successful achievement of such treatment goals following active periodontal treatment provided that a tailored supportive program is instituted and regularly attended (Lindhe & Nyman, 1984; Axelsson, Nystrom, & Lindhe, 2004).

The very long observation time necessary to evaluate the likelihood of future progress of the disease and tooth loss makes it difficult to carry out long-term prospective studies. Thus, clinical attachment level (CAL) gain and probing depth (PD) reduction are commonly used as surrogate clinical endpoints to monitor the short- and medium-term response to periodontal therapy (Greenstein, 2005; Hujoel, 2004). It is expected that successful surrogate outcomes are predictive of reduced tooth loss due to periodontitis (Matulienė et al., 2008; Tomasi & Wennstrom, 2017). Whereas CAL reflects the amount of past periodontal destruction that will not be necessarily recovered following successful periodontal treatment, PD is expected to improve significantly after periodontal therapy (Kolakovic, Held, Schmidlin, & Sahrman, 2014). Residual pockets of > 4 mm, especially when associated with persisting bleeding on probing (BoP), are at an increased risk for losing CAL than shallow pockets and require additional treatment (Claffey Nylund, Kiger, Garrett, & Egelberg, 1990; Matulienė et al., 2008; Westfelt, Rylander, Dahlen, & Lindhe, 1998). In contrary, shallow PDs and the absence of clinical inflammation are forecaster of long-term stability and tooth retention (Badersten, Nilveus, & Egelberg, 1990; Claffey & Egelberg, 1995; Lang, Adler, Joss, & Nyman, 1990; Lang & Tonetti, 2003).

In residual periodontal pockets associated with shallow intrabony defects, where the regenerative treatment is not indicated, the osseous resective surgery (ORS) with Apically Positioned Flap (Ochsenbein, 1958) resulted in lower incidence of disease progression in the long-term period compared with conservative surgery (Becker et al., 1988; Kaldahl,

Kalkwarf, Patil, Molvar, & Dyer, 1996a; Kaldahl, Kalkwarf, Patil, Molvar, & Dyer, 1996b; Ramfjord, Knowles, Nissle, Burgett, & Shick, 1975). The goals of ORS are not only to eliminate bony defects by restoring positive bone architecture at a more apical position but also to restore a physiological bone and gingival contour enhancing proper oral hygiene and periodontal health (Carnevale, 2007; Carnevale & Kaldahl, 2000). These clinical outcomes are usually assessed in terms of changes in the above-mentioned surrogate variables (CAL and PD) and expressed as mean and standard deviation. However, CAL gain and PD reduction are strictly related to the baseline parameters and do not provide information on the risk of further disease progression.

Pocket closure, i.e. the reduction of PD to a level of up to 4 mm, represents the clinical endpoint for treatment success (Tomasi & Wennstrom, 2017). In a large retrospective cohort study with a mean follow-up of 11 years the presence of at least one site with residual PD  $\geq$  5 mm was found to contribute significantly to the risk of periodontitis progression in the long term (Matuliene et al., 2008). When considering predictors for future tooth loss, teeth with the deepest PD  $\geq$  5 mm at the end of the active therapy yielded a statistically significant higher risk to be lost and the risk increased every millimetre (Matuliene et al., 2008). In resection treatment modalities the closure of sites with PD  $\geq$  5 mm is achieved by the removal/reshaping of soft/hard-tissue wall defects resulting in recession increase and loss of clinical attachment as biological cost (Cairo et al., 2013). Thus, the term “pocket elimination” appears to be more appropriate in ORS procedures (Graziani, Karapetsa, Mardas, Leow, & Donos, 2018).

What is currently lacking is an overall estimate of the percentage of pocket elimination following ORS as based on the available published literature. Therefore, the aim of this research was to systematically review the literature about the clinical performance of ORS in the treatment of residual periodontal defects in terms of pocket elimination and biological costs.

## **Materials and Methods**

### ***Protocol development and focused question***

This systematic review was conducted according to the Cochrane Handbook (Higgins & Green, 2011) and reported according to the PRISMA statement recommendations (Moher, Liberati, Tetzlaff, Altman, 2009, see Supplementary Table 1). The protocol was registered on the PROSPERO database: CRD42017071702 ([www.crd.york.ac.uk/PROSPERO](http://www.crd.york.ac.uk/PROSPERO)).

The literature search was conducted to answer the following focused question: “*In systemically healthy patients with chronic periodontitis which is the efficacy of ORS to obtain pocket elimination in the treatment of residual periodontal defects and how high is the biological cost for patients?*”

Following the PICO criteria, subjects with chronic periodontitis (ChP) were considered as the population. ORS without or with Fibre Retention technique (Carnevale, 2007) was considered as the Intervention. No comparison was made. Percentage of pocket elimination at 12 months (i.e. percentage of periodontal pockets with initial PD  $\geq$  5 mm which converted to PD  $\leq$  4 mm after treatment) was defined as the primary outcome. Biological costs in term of amount of osteotomy, increase in gingival recession (Rec) at 12 months, and patient related outcome measures (PROMs) were considered as secondary outcomes.

### ***Eligibility criteria***

Inclusion criteria and exclusion criteria were defined a priori. The inclusion criteria were as follows: 1) English language; 2) Retrospective studies, case-control studies, case series, randomized controlled (RCT) and non randomized controlled (non-RCT) studies (split-mouth or parallel group design) investigating the clinical efficacy of ORS without or with Fibre Retention technique (FibReORS) in the treatment of intrabony defects. Data from control group, if any, were not considered; 3) Follow-up duration of at least 12 months; 4) Systemically healthy subjects diagnosed with ChP based on the criteria described by the 1999

International World Workshop for a Classification of Periodontal Disease and Conditions (Armitage, 1999); 5) Studies reporting clinical outcomes in terms of PD changes.

Exclusion criteria included: 1) Studies enrolling heavy smokers (> 20 cigarettes/day); 2) Inclusion of less than 10 patients; 3) Studies focusing only on furcation involved teeth; 4) Studies on aggressive periodontitis patients because they might respond differently to periodontal treatment (Deas & Maley, 2010).

### ***Information sources and search***

An electronic search of three databases (MEDLINE via PubMed, EMBASE via Ovid and Cochrane Central Register of Controlled Trials (CENTRAL)) was performed until 28<sup>th</sup> January 2019.

The strategy used was a combination of medical subject headings (Mesh) terms and free text words as reported in Table 1. The search strategy was developed with a medical librarian with extensive experience in designing searches for systematic reviews. The search strategy was first designed for the MEDLINE database and was then modified appropriately for the other databases searched.

Hand searching was also performed on *Journal of Clinical Periodontology*, *Journal of Dental Research*, *Journal of Periodontal Research*, *Journal of Periodontology*, and *The International Journal of Periodontics and Restorative Dentistry* up to January 2019 and on reference lists of all retrieved papers for full text screening and previous reviews.

The search results were downloaded to a bibliographic database and duplicate records were removed. Titles and abstracts of all identified studies were screened for eligibility by two of the review authors (M.G., F.F.) in duplicate and independently. Subsequently the full text of all the articles meeting the inclusion criteria or for which there was not sufficient information in the title and abstract were obtained and screened in duplicate and independently by the same review examiners, previously calibrated. Any disagreement was resolved with discussion between both reviewers until consensus was reached or through arbitration by a

third examiner (F.R.). Relevant articles were analysed in full-text and disagreement was discussed with a third examiner (F.R.). The level of agreement was calculated using the k-score.

In case of unclear or missing data a letter was sent to the corresponding author to obtain the needed information to aid the final decision. If no reply was received within 3 weeks, the respective study was excluded.

### ***Data collection***

Data extraction of the included papers was performed independently by the same two review authors (M.G., F.F.) in a predefined and piloted collection form. Any disagreement was resolved by discussion with a third author (F.R.). When the study results were published more than once or were detailed in multiple publications the most complete data set was included. The extraction sheet included the following study details: authors name, year of publication, study design, setting and funding, follow-up duration, number of participants, demographic information, periodontal status, smoking habits, type of intervention (ORS or FibReORS), original primary and secondary outcomes of the study, number of sites with PD  $\geq$  5 mm at baseline, number of sites with PD  $\leq$  4 mm at 12 months after treatment, percentage of pocket elimination at 12 months, mean PD, mean CAL and mean Rec at baseline and at 12 months, mean osteotomy and PROMs including experience of the treatment, pain, discomfort and preferences. When information on pocket elimination was not provided, calculations were performed based on the raw data reported in the paper or collected by the authors.

### ***Risk of bias assessment***

The risk of bias of non-RCTs had to be assessed with Newcastle-Ottawa scale (Wells et al., 2012), but non-RCTs were not identified. A quality assessment of RCTs was performed independently by both review authors (M.G., F.F.) according to the Cochrane collaborations' tool (Higgins & Green, 2011) for assessing the risk of bias (low, high, unclear) including the following six domains: (i) sequence generation, (ii) allocation concealment, (iii) blinding of

participants, personnel and outcome assessors (iv), handling of incomplete outcome data, (v) selective reporting and (vi) other sources of bias. Accordingly, the quality of each study was rated as poor to high. A study was evaluated as having high quality if all criteria were met, it was graded as fair quality if one of the criteria was not met or if two criteria were unclear, and poor quality if two or more criteria were listed as high or unclear risk of bias.

Other sources of bias including study design, source of funding, location of the study, skill of the operators, examiner calibration, statistical analysis, smoking habits, patient's proficiency in plaque control, and supportive periodontal treatment were considered.

### ***Data analysis***

To summarize studies, they were combined in order to perform meta-analyses reporting weighted means and 95% confidence intervals (CI) to estimate percentage of pocket elimination at 12 months, amount of bone resection and Rec increase at 12 months. Subgroup analyses were performed on the selected outcome variables using study design, smoking habits, risk of bias, and surgical techniques (conventional ORS vs. FibReORS) as explanatory variables. The statistical heterogeneity among studies was assessed using the Q test based on chi-square statistics (Cochran, 1954) as well as the I<sup>2</sup> index (Higgins, Thompson, Deeks, & Altman, 2003) in order to know the percentage of variation in the global estimate that is attributable to heterogeneity.

Due to the limited number of studies in the analyses, formal testing for publication bias was not possible. Study specific estimates were pooled with the random-effect models. A Forest Plot was created to illustrate the effects of the different studies and the global estimation. OpenMeta [Analyst] software was used to perform all analyses.

## **Results**

### ***Study selection***

The electronic search determined a total of 2585 articles that reduced to 1765 after duplicate removal (Figure 1). No further articles were identified by hand searching. Screening of titles

and abstracts led to rejection of 1712 articles, and then the full text of the remaining 53 articles was obtained. The agreement between two reviewers was excellent ( $k$ -score = 0.859). After exclusion of further 43 studies (list of excluded studies and reasons for exclusion are reported in Supplementary Table 2) the full text of the remaining 10 articles was analysed for availability of data for meta-analysis and for methodological quality. All met the inclusion criteria, but data on pocket elimination were missing in 9 papers. Only two corresponding authors sent the raw data of three papers. Lastly, 4 articles (Aimetti et al., 2015; Aimetti et al., 2016; Becker et al., 1988; Cairo et al., 2013) were included in the review.

### ***Characteristics of included study***

All the information about included studies is summarized in the Table 2. All included studies were RCTs conducted at a university setting; three employed a split-mouth design (Aimetti et al., 2015; Aimetti et al., 2016; Becker et al., 1988) and one used parallel groups (Cairo et al., 2013). The number of enrolled patients was between 13 and 16. Two studies compared ORS without and with fibre retention technique (Aimetti et al., 2015; Cairo et al., 2013), one study two different bone remodelling modalities by using burs and piezosurgery (Aimetti et al., 2016) and one study (Becker et al., 1988) compared scaling and root planing, osseous surgery and the modified Widman flap procedure. Only one study (Becker et al., 1988) reported frequency distribution of PD changes for 1-3 mm, 4-6 mm and >6 mm initial pockets, while the remaining three studies presented average data. In all included studies patients underwent non-surgical periodontal treatment (sessions of oral hygiene motivation, scaling and root planing) that was completed 4-6 weeks (Becker et al., 1988), 2 months (Cairo et al., 2013) or at least 3 months (Aimetti et al., 2015; Aimetti et al., 2016) before the surgical treatment was planned. All the enrolled patients displayed at baseline full mouth plaque score and full mouth bleeding score values < 15% indicating a good standard of supragingival plaque control. Furthermore, all studies incorporated regular maintenance care in their protocols with professional prophylaxis at 3-month intervals for a period up to 1 year following surgical



procedures.

### ***Quality of reporting***

All included studies were evaluated according to the Cochrane Collaboration tool, and Table 3 summarizes this analysis. Three studies (Aimetti et al., 2015; Aimetti et al., 2016; Cairo et al., 2013) were classified as having low risk of bias for all criteria analysed. One study (Becker et al., 1988) presented high risk of bias for sequence generation and blinding and unclear risk of bias for allocation concealment and handling of incomplete outcomes. Thus, it was classified as having low quality.

### ***Synthesis of the results***

#### *Pocket elimination (PD $\leq$ 4 mm)*

Percentage of pocket elimination was calculated from raw data provided by the authors of three studies (Aimetti et al., 2015; Aimetti et al., 2016; Cairo et al., 2013). Data from both test and control groups were separately considered in the meta-analysis for a total of 6 data sets. Since clinical outcomes noted by Becker et al. (1988) were stratified on PD categories not considered in the present meta-analysis, this study was not included in the quantitative analysis.

The meta-analysis pooled data from 45 ChP patients and 80 sextants at baseline, and all completed the 12-month experimental period. Two studies with 4 data sets (Aimetti et al., 2016; Cairo et al., 2013) reported a 100% elimination of pockets  $\geq$  5 mm (Table 3). Aimetti et al. (2015) obtained a 94.03% elimination of pockets  $\geq$  5 mm with ORS and a 93.33% with FibReORS. As depicted in Figure 2, random-effects meta-analysis showed an overall weighted mean percentage of pocket elimination of 98.3% (95% CI: 96.8; 99.7) after resective surgery without significant heterogeneity ( $I^2 = 26\%$ ,  $P = 0.400$ ).

Subgroup analysis failed to obtain homogeneity considering the contribution of study design, and smoking habits, while obtained homogeneity for ORS procedure ( $I^2 = 0\%$ ,  $P = 0.545$ ) (Figure 2). ORS and FibReORS were equally effective in eliminating periodontal pockets.

### *Ostectomy and recession increase*

Data on ostectomy were gathered by two RCTs (Aimetti et al., 2015; Aimetti et al., 2016) with four data sets (Figure 3) Overall, the weighted mean amount of resected bone after resective surgery was 0.89 mm (95% CI: 0.49; 1.25). It was 1.04 mm (95% CI: 0.93; 1.14) at sites treated with ORS and 0.40 mm (95% CI: 0.21; 0.51) at sites treated with FibReORS. However, only one study was available for FibReORS. The comparisons presented a low heterogeneity among the selected studies with ORS procedure ( $I^2 = 0\%$ ,  $P = 0.661$ ).

Forest plots of Rec increase after osseous resective surgical interventions are depicted in Figure 4. Three RCTs (Aimetti et al., 2015; Aimetti et al., 2016; Cairo et al., 2013) with six data sets contributed to Rec increase calculation at 12 months. Overall, the weighted mean Rec increase after resective surgery was 2.13 mm (95% CI: 1.49; 2.78) with high heterogeneity ( $I^2 = 88\%$ ,  $P < 0.001$ ). Subgroup analysis, that would suggest higher Rec increase for ORS (2.33 mm, 95% CI: 1.53; 3.14) than for FibReORS (1.72 mm, 95% CI: 0.15; 3.28), failed to obtain homogeneity showing  $I^2$  of 87% and 93% for ORS and FibReORS, respectively.

### *PROMs*

All studies reported data on PROMs and used the Visual Analogue Scale (VAS) to score pain experienced during surgery and during the first postoperative weeks. The chair time was similar between the two procedures (about 60 minutes) and no difference in perceived intrasurgical pain was reported (Aimetti et al., 2015; Cairo et al., 2013). Patients felt the ORS procedure harder than FibReORS at the end of the surgery in the study by Cairo et al. (2013). When analysing the early healing phase, patients experienced significantly greater pain in the ORS-treated sites during the first week (Cairo et al., 2013) or during the first two weeks post surgery (Aimetti et al. 2015). The first postoperative week was considered less painful in sextants where ORS was performed using a piezosurgery device as compared to rotary instruments (Aimetti et al., 2016).

At 2 weeks (Cairo et al., 2013) and at 4 weeks (Aimetti et al., 2013) pain was not longer reported for both procedures, while at one year ORS still had a significantly higher VAS scores for hypersensitivity (Cairo et al., 2013). Cairo et al. (2013) reported additional data on patient's satisfaction at 12 months with higher rates for FibReORS.

## **Discussion**

The present systematic review analysed the 12-month effect of ORS procedures in the management of residual periodontal defects in terms of pocket elimination and biological costs in patients with ChP. From our knowledge this is the first systematic review addressing this clinically relevant topic.

Given that the endpoint of ORS are to recreate soft tissue contours allowing for proper self-performed oral hygiene and to obtain minimal PDs by reshaping intrabony defects to positive bone architecture (Carnevale & Kaldhal, 2000), we considered pocket elimination (final PD  $\leq$  4 mm) as the clinical outcome to be evaluated (Tomasi, Leyland, & Wennstrom, 2007). However, the majority of studies in the literature reported outcomes in terms of average PD changes, from which it is not possible to draw any conclusion on the efficacy of treatment in changing the prognosis at the tooth and site level (Lang & Tonetti, 2003).

Since many sites will show no or minimal change, calculating a full-mouth mean value will both lose information and not adequately characterize periodontal health. Pathological PD and BoP are risk factors for further CAL loss (Claffey et al., 1990; Matuliene et al., 2008). Thus, successful clinical endpoint of any periodontal treatment would be shallow PD without BoP, which would indicate effective removal of subgingival biofilm/calculus and clinical resolution of the inflammatory lesion. Although positive BoP represents a risk factor at site level for CAL loss with an odds ratio of 2.79 (Armitage, 1996), it is noteworthy that no studies reported results in terms of composite outcome (residual PD and absence/presence of BoP).

Furthermore, it is important to establish a threshold value for pocket elimination, because cut-off points impact on the definition of successful therapy. Considering the threshold value for pocket closure in non-surgical and regenerative periodontal treatments (Graziani et al., 2018; Tomasi, Leyland, & Wennstrom, 2007), we used a cut-off value of  $PD \leq 4$  mm as clinical endpoint. It is suggestive of clinical stability and long-term tooth maintenance. A previous long-term retrospective study demonstrated that in subjects receiving a maintenance therapy for 10 years or longer only residual PDs  $\geq 5$  mm were associated with a significantly higher risk of tooth loss (Matuliene et al., 2008).

Several papers were excluded from the present systematic review due to the short duration of the follow-up (less than 12 months, see Supplementary Table 2). It has been demonstrated that 12 months is the healing period necessary for creeping attachment to occur after apically positioned flap surgery and osseous resection (Aimetti et al., 2018; Cairo et al., 2015; Pontoriero & Carnevale, 2001). The post-surgical soft tissue recession is directly proportional to the severity of the pre-surgical PDs on the buccal, lingual and interproximal surfaces and it decreases during the first postoperative year due to the coronal displacement of the gingival margin from the immediate post-surgical level (Aimetti et al., 2015; Cairo et al., 2015). This post-surgical tissue regrowth occurred in conjunction with change in PD and CAL values as compared with those recorded immediately after surgery during the first 6 to 12 months of healing (Kaldhal, Kalkwarf, Patil, Dyer, & Bates, 1988; Lindhe, Socransky, Nyman, & Westfelt 1987). After that period the gingival margin remained unchanged during 5 to 7 years of maintenance (Kaldhal et al., 1996a; Townsend, Ammons, & Van Belle, 1985).

The meta-analysis was based on data from three RCTs with low risk of bias (and six data sets) reporting a percentage of pocket elimination between 93.33% and 100% at 12 months with an overall weighted mean value of 98.3% (95% CI: 96.8; 99.7). The use of the fibre retention technique would not seem to increase the proportion of sites with final  $PD \leq 4$  mm.

We included the paper by Becker et al. (1988) in the systematic review but not in the meta-analysis because other cut-off values than ours were chosen than rendered the comparison impossible. In addition, it presented a high risk of bias due to several methodological aspects, such as sequence generation, allocation concealment and blinding of the examiners. The surgical technique was not clearly defined but it is advisable that it was different from that performed in the other more recent studies, and no information was provided on smoking habits. Smoking is proven to negatively affect all modalities of non-surgical and surgical periodontal therapy (Heasman et al., 2006) and to decrease the probability of pocket closure/reduction after non-surgical treatment (Tomasi et al., 2007).

The benefits of ORS treatment always have to be balanced with their biological costs. Overall, the weighted mean amount of resected bone was 0.87 mm (95% CI: 0.49; 1.25) and the weighted mean increase in Rec was 2.13 mm (95% CI: 1.49; 2.78) at 12 months. The use of the fibre retention technique reduced the extent of bone removal (0.40 mm vs. 1.04 mm) and the final Rec (1.72 mm versus 2.33 mm) when compared to conventional ORS technique. The less extent of bone removal in the FibReORS group is attributable to the preservation of the supracrestal connective tissue fibre attachment (Carnevale, 2007).

It should be also taken into account that differences in the bone remodelling procedure can lead to a different amount of soft-tissue rebound during the follow-up period (Aimetti et al., 2018). In this context, the position of the gingival margin in relation to the level of the reshaped alveolar crest can also affect the final amount of soft-tissue regrowth and PD reduction as described in previous studies on crown lengthening procedure (Bragger, Pasquali, & Kornman, 1988; Pontoriero & Carnevale, 2001). However, the significant heterogeneity between the included studies prevented to draw any definitive conclusion.

Another aspect to take into account is the time interval between non-surgical treatment and surgery. In the studies included in the meta-analysis the need for surgical intervention was assessed 2 to 3 months after subgingival instrumentation. Previous clinical studies

documented on combinations of suprabony and intrabony defects that mean PD and CAL values continued to improve during 6-9 months following the start of non-surgical treatment, while Rec values increased more during the first 3 months (Badersten, Nilvéus, & Egelberg, 1984; Cercek, Kiger, Garrett, & Ehelberg, 1983). Thus, it has been suggested to wait at least 6 months before planning any additional treatment (Badersten, Nilvéus, & Egelberg, 1984). However, considering the anatomy of the bony defects treated with ORS, the presence of persisting pathological pockets (PD  $\geq$  5 mm and BoP) is predictable of further periodontitis progression over long time frame (Matuliene et al., 2008). In addition, re-instrumentation of sites that responded poorly to the non-surgical treatment is successful in only 11-16% of the pockets (Wennström, Tomasi, Bertelle, & Dellasega, 2005).

Patient's opinion is a fundamental measure of therapeutic success along with the various traditional clinical endpoints (Ng & Leung, 2006). PROMs are reported to be more relevant to patient's daily lives than objective changes in PD or CAL (Naito et al., 2006).

Pain is common but not always present after resective surgery, although it is generally moderate in most patients. It is mostly pronounced the day after surgery, then it tends to gradually decrease until it completely disappears within 2 to 4 weeks (Aimetti et al., 2015; Cairo et al., 2013). FibReORS seems to be less painful than conventional ORS, which is more painful when ostectomy is performed using burs than piezosurgery devices (Aimetti et al., 2016). Technical differences with different bone tissue exposure may account for different pain experiences after those two procedures (Carnevale, 2007). The lower expression of cytokines in the epithelium and connective tissue of FibReORS-treated sites may be beneficial to reduce the postsurgical intensity of the host-mediated inflammatory response in the early wound-healing phase (Romano et al., 2017).

It is worth noting that the experienced pain/discomfort is not related to the duration of the surgery (Aimetti et al., 2015; Cairo et al., 2013) and that dentin hypersensitivity persists after pain resolution until one year after surgery in ORS-treated sextants (Cairo et al., 2013). The

higher amount of resected bone and the corresponding more severe recessions may concur to explain the greater overall patients' satisfaction for FibReORS than ORS (Cairo et al., 2013).

While these data are clinically promising, the limited number of studies available for the meta-analysis, with more data sets coming from the same studies, represents the major limitation of this study. In addition, other limitations are evident: 1) language restriction leading to inclusion only of studies in English (7 studies in Japanese, Turkish and French were excluded, see Supplementary Table 3); 2) high heterogeneity for secondary outcomes; 3) most of the evidence gathered from studies of the same authors; 4) data in the enclosed studies referred to the sextants that underwent ORS and not only to the sites in which bone recontouring was carried out.

Within the limitations of the research, it can be concluded that ORS represents an effective surgical approach for elimination of residual periodontal pockets in posterior sextants in the short- to medium-term. The use of fibre retention technique is associated with comparable pocket elimination percentage but less marginal bone resection, less final Rec and less patient morbidity than conventional ORS.

Due the low number of the included studies and to the significant heterogeneity, the overall estimates from the meta-analyses, despite representing best-available evidence, should be used with caution and likely represent a low strength of evidence. Anyway, it is important to underline that data considering final PD  $\leq$  4 mm were consistent among the studies in which ORS was planned 2-3 months after non-surgical therapy.

This review highlights the need of more trials that use pocket elimination and PROMs as clinical endpoint to evaluate the efficacy of ORS and to monitor patients over time, and the importance of the availability of raw data. Further long-term randomized controlled clinical trials are needed to strengthen the evidence and to evaluate the impact on pocket elimination of factors that are known to influence the healing pattern such as smoking habits, surgical skill, surgical technique, tooth anatomy, and supportive periodontal therapy program.

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**Table 1. Algorithm for electronic search**

Focused question	“In patients with chronic periodontitis which is the outcome after osseous resective surgery in terms of percentage of pocket elimination (i.e. PD ≤ 4 mm) and biological costs?”
Medline via Pubmed	((((osseous OR hard-tissue OR bone) AND (resective OR recontouring OR recontour OR resection)) OR osseous-surgery OR fiber-retention OR fibre-retention) AND (“Periodontium”[Mesh] OR “Periodontal Diseases”[Mesh] OR periodontal OR periodontic OR periodontics OR periodontitis OR periodontology OR probing-depth OR probing-depths OR pocket OR pockets OR alveolar)) OR (pocket-elimination OR pocket-reduction OR pocket-closure)
Embase via Ovid	((((osseous OR hard-tissue OR bone) AND (resective OR recontouring OR recontour OR resection)) OR osseous-surgery OR fiber-retention OR fibre-retention) AND ('periodontium'/exp OR 'periodontal disease'/exp OR periodontal OR periodontic OR periodontics OR periodontitis OR periodontology OR probing-depth OR probing-depths OR pocket OR pockets OR alveolar)) OR (pocket-elimination OR pocket-reduction OR pocket-closure)
Cochrane	<p>#1 (osseous OR hard-tissue OR bone):ti,ab,kw</p> <p>#2 (resective OR recontouring OR recontour OR resection):ti,ab,kw</p> <p>#3 #1 AND #2</p> <p>#4 (osseous-surgery OR fiber-retention OR fibre-retention):ti,ab,kw</p> <p>#5 #3 OR #4</p> <p>#6 MeSH descriptor: [Periodontium] explode all trees</p> <p>#7 MeSH descriptor: [Periodontal Diseases] explode all trees</p> <p>#8 (periodontal OR periodontic OR periodontics OR periodontitis OR periodontology OR probing-depth OR probing-depths OR pocket OR pockets OR alveolar):ti,ab,kw</p> <p>#9 #6 OR #7 OR #8</p> <p>#10 #5 AND #9</p> <p>#11 (pocket-elimination OR pocket-reduction OR pocket-closure):ti,ab,kw</p> <p>#12 #10 OR #11</p>
Limits	Humans; Not review; English

**Table 2. Characteristics of included studies**

First author, publication year	Study design	Sample size	Mean age	Gender	Diagnostic criteria	Type of surgery	Smoking habits	Primary outcome	Secondary outcome	Site and funding	PD mean ± SD (mm)	CAL mean ± SD (mm)	Rec mean ± SD (mm)	Ostectomy mean ± SD (mm)
Becker et al. (1988)	split-mouth RCT	16 patients (group ORS)	42 (30-57)	11E, 5M	CAL loss >5mm	ORS	Not specified	CAL, PD	PI, GI	Michigan University	Baseline PD <3mm: 2.39 PD 4-6mm: 4.87 PD ≥7mm: 7.11 1y PD <3mm: 2.24±0.34 PD 4-6mm: 3.23±0.71 PD ≥7mm: 4.09±1.32	Baseline PD <3mm: 1.58 PD 4-6mm: 3.83 PD ≥7mm: 5.64 1y PD <3mm: 2.4±0.71 PD 4-6mm: 3.44±0.84 PD ≥7mm: 5.05±1.77	N.A.	N.A.
Cairo et al. (2013)	RCT	15 patients (group ORS) a	51.6 ± 10.6 (34-62)	10E, 5M	PD >5mm, BoP+, infrabony defect <3mm	ORS	≤20 sig/die (6/15 smokers)	PD, Rec	resected bone, radiographic bone changes, surgical time, intra-operative and post-operative factors of morbidity	Florence University	Baseline 3.1 ± 1.6 1y 2.2 ± 0.8	N.A.	Baseline 1.2 ± 1.1 1y 3.5 ± 1.2	N.A.
		15 patients (group FibReORS) b	47.6 ± 10.3 (30-63)	11E, 3M	FibReORS	≤20 sig/die (9/15 smokers)					Baseline 2.9 ± 1.6 1y 2.1 ± 0.8	N.A.	Baseline 1.2 ± 1.0 1y 2.1 ± 0.8	N.A.
Aimetti et al. (2015)	split-mouth RCT	13 patients (group ORS) a	48.4 ± 4.7	10E, 3M	PD >5mm, BoP+, infrabony defect <3mm	ORS	No smokers	CAL	PD, Rec, PI, BoP, KT, radiographic bone changes	Turin University	Baseline 3.4 ± 0.6 1y 2.3 ± 0.5	Baseline 3.7 ± 0.8 1y 6.1 ± 1.0	Baseline 0.3 ± 0.5 1y 3.8 ± 1.0	1.0 ± 0.3
		FibReORS				Baseline 3.6 ± 0.6 1y 2.1 ± 0.4					Baseline 3.8 ± 1.0 1y 4.8 ± 0.8	Baseline 0.2 ± 0.5 1y 2.7 ± 0.7	0.4 ± 0.2	
Aimetti et al. (2016)	split-mouth RCT	12 patients (group ORS a) a	50.8 ± 8.5 (41-63)	5F, 7M	PD >5mm, BoP+, infrabony defect <3mm	ORS	<7 sig/die (2/12 smokers)	IL-1	PD, CAL, Rec, PI, BoP	Turin University	Baseline 3.7 ± 0.9 1y 2.1 ± 0.5	Baseline 4.2 ± 0.9 1y 4.5 ± 0.7	Baseline 0.5 ± 0.6 1y 2.4 ± 0.7	1.1 ± 0.3
		12 patients (group ORS rotary bur) b									Baseline 3.4 ± 0.7 1y 1.9 ± 0.4	Baseline 4.0 ± 0.8 1y 4.2 ± 0.8	Baseline 0.6 ± 0.4 1y 2.3 ± 0.6	1.0 ± 0.4

RCT: Randomized Clinical Trial; ORS: Osseous Resective Surgery, FibReORS: Fibre Retention Osseous Resective Surgery, PD: Pocket Depth; CAL: Clinical Attachment Level; Rec: Gingival Recession; IL-1: Interleukin-1; PI: Plaque Index; KT: Keratinized Tissue; BoP: Bleeding on Probing; SD: Standard Deviation; N.A.: not available.

**Table 3. Risk of bias in individual studies**

<b>First author, year</b>	<b>Sequence generation</b>	<b>Allocation concealment</b>	<b>Blinding of participants personnel and outcome assessors</b>	<b>Handling of incomplete outcome</b>	<b>Selective reporting</b>	<b>Other bias</b>	<b>Risk of Bias</b>
Becker et al. (1988)	High	Unclear	High	Unclear	Low	Unclear	Poor quality
Cairo et al. (2013)	Low	Low	Low	Low	Low	Low	Good quality
Aimetti et al. (2015)	Low	Low	Low	Low	Low	Low	Good quality
Aimetti et al. (2016)	Low	Low	Low	Low	Low	Low	Good quality

### **Figures Legends**

Figure 1. Prisma flow chart of selection process.

Figure 2. Forest plot from random effects of meta-analysis on the percentage of pocket elimination ( $PD \leq 4$  mm) 12 months after osseous resective surgery, subgroup analysis, effect of surgical procedures.

Figure 3. Forest plot from random effects of meta-analysis on the amount of ostectomy after osseous resective surgery, subgroup analysis, effect of surgical procedures.

Figure 4. Forest plot from random effects of meta-analysis on the mean recession increase 12 months after osseous resective surgery, subgroup analysis, effect of surgical procedures.

### **Supplementary Tables**

Supplementary Table 1. Checklist according to PRISMA statement.

Supplementary Table 2. Full-text articles excluded with reasons.

Supplementary Table 3. Articles excluded for language reason (no English)

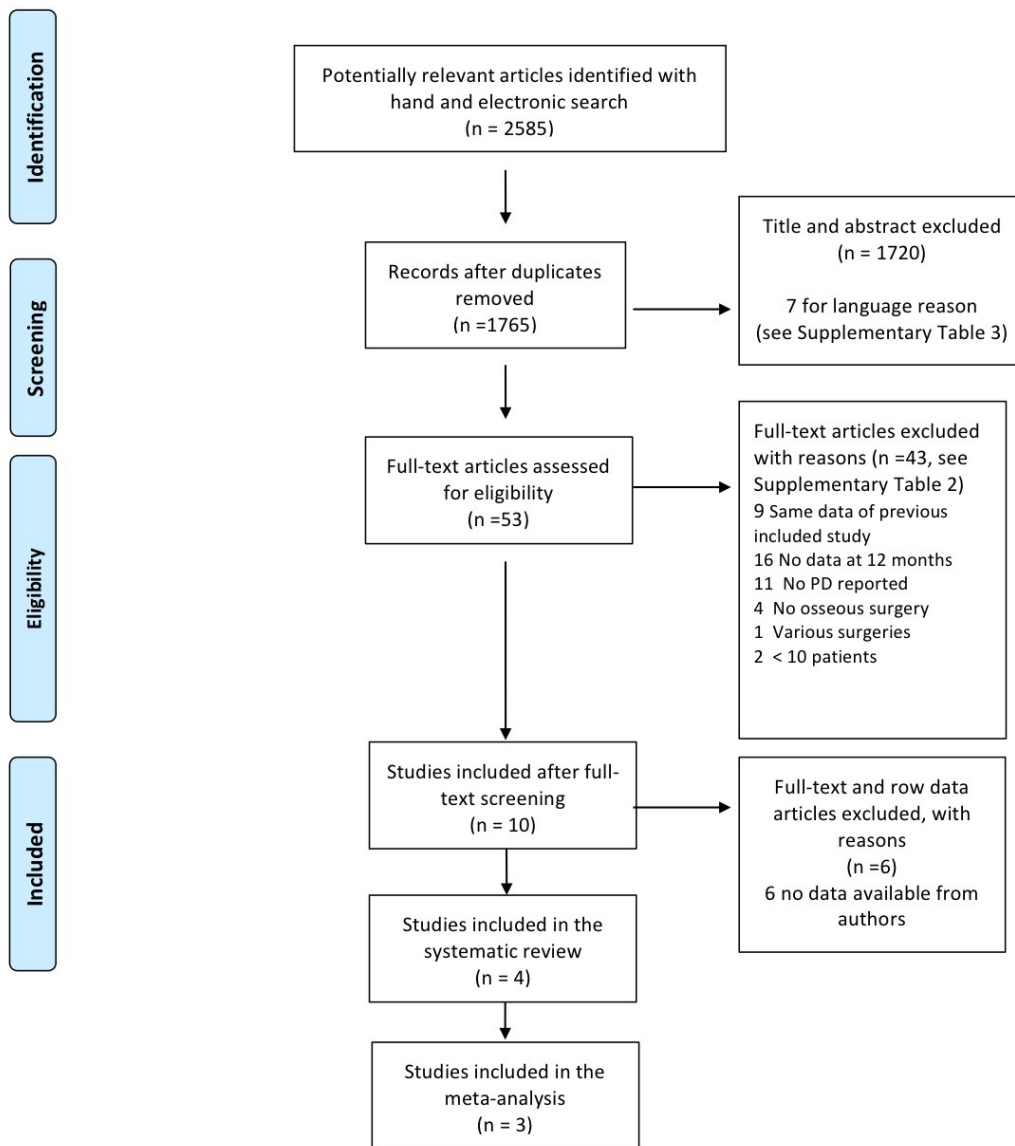


Figure 1

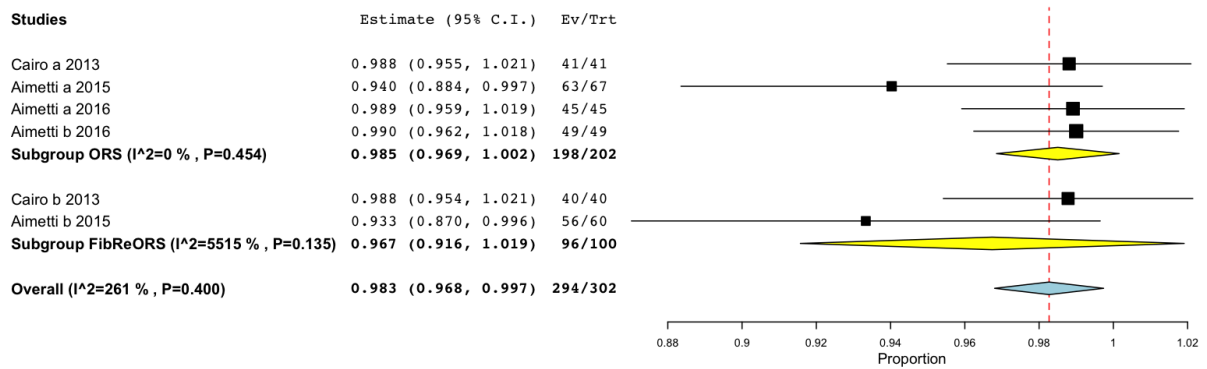


Figure 2

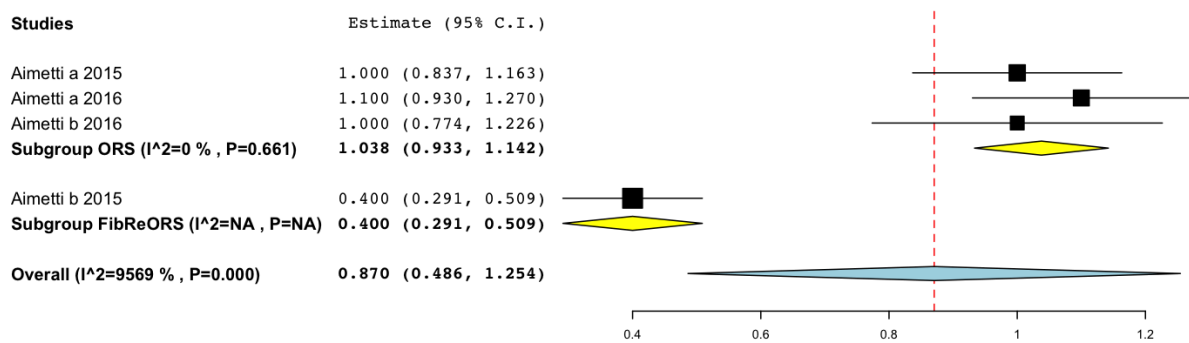


Figure 3

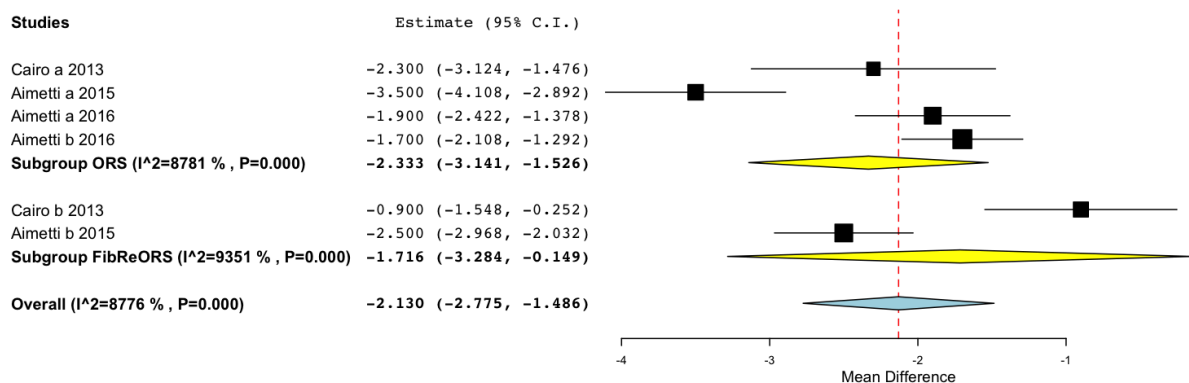


Figure 4