DR. CHO-YING LIN (Orcid ID : 0000-0003-2499-6191)

DR. ZHAOZHAO CHEN (Orcid ID : 0000-0002-2188-1367)

PROF. HOM-LAY WANG (Orcid ID : 0000-0003-4238-1799)

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The effect of supportive care in preventing peri-implant diseases and implant loss: A Systematic review and Meta-analysis

Running head: The effect of supportive post-implant treatment

Cho-Ying Lin, DDS[1], Zhaozhao Chen, DDS, MS[2], Whei- Lin Pan, DDS [3], Hom-Lay Wang, DDS, MS, PhD [2,4]

[1] Attending, physician of department of Periodontics, Chang Gung Memorial Hospital, Taipei, Taiwan. Faculty, Chang Gung University, Taoyuan city, Taiwan

[2] Postgraduate Student, Department of Periodontics and Oral Medicine, School of Dentistry, University of Michigan, Ann Arbor, MI, USA.

[3] Chair, Taipei Chang Gung Memorial Hospital, Department of Periodontics, Taipei, Taiwan. Faculty, Chang Gung University, Taoyuan city, Taiwan

[2,4] Professor and Director of Graduate Periodontics, Department of Periodontics and

Oral Medicine, School of Dentistry, University of Michigan, Ann Arbor, MI, USA. Visiting Professor, State Key Laboratory of Oral Diseases, National Clinical Research Center for Oral Disease, Department of Prosthodontics, West China Hospital of Stomatology, Sichuan University, Chengdu, PR China

Correspondent author:

Dr. Cho-Ying Lin, Attending physician of department of Periodontics, Chang Gung Memorial Hospital, Taipei, Taiwan. Faculty, Chang Gung University, Taoyuan city, Taiwan. TEL: 734-8464219; Email: jessicalin1020@gmail.com

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CY.L. conceived the ideas

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CY.L. and ZZ.C. analysed the data

CY.L. , ZZ.C. and HL. W. led the writing

ABSTRACT:

Objective: To evaluate the influence of supportive treatment (SPT) during a maintenance period after implant placement on implant survival rate and incidence of peri-implant diseases.

Material and Methods: A systemic literature search for studies published up to June 2018 was conducted by two independent reviewers using Pubmed/MEDLINE, EMBASE and Cochrane Central databases. Clinical controlled trials (CCT) involved in SPT protocol with more than 1-year follow-up were included. Quantitative meta-analyses were carried out to analyze the risk ratio (RR) of survival rate (SR), the incidence of peri-implantitis and peri-implant mucositis between SPT and non-SPT groups. Any potential confounding factors were investigated using meta-regression.

Results: Nine CCTs fulfilled the criteria. To evaluate the influence of SPT on SR, peri-implantitis and peri-implant mucositis, 6 of 9, 3 of 9 and 3 of 9 articles were included in further meta-analysis, respectively. SPT group significantly showed higher SR (RR: 1.10; $p<0.001$), lower prevalence of peri-implantitis (RR: 0.25; $p<0.001$) and peri-implant mucositis (RR: 0.57; $p<0.001$) than the non-SPT group. Meta-regression of the selected studies failed to find an association between SR, peri-implantitis and peri-implant mucositis and confounding factors: application of chemical agents and the frequency of SPT.

Conclusion: SPT can potentially improve peri-implant health in terms of SR, peri-implantitis and peri-implant mucositis. Additionally, the correlation in recall interval and adjunctive use of chemical agents during SPT to peri-implant diseases and implant loss could not be found.

Keywords: supportive treatment; maintenance; peri-implantitis; survival rate; systematic review and meta-analysis

INTRODUCTION:

Peri-implant diseases such as peri-implantitis (PI) has recently gained much attention due to uprising prevalence. Recent consensus has concluded plaque as the main cause of peri-implant mucositis and PI (Berglundh et al 2018). Similar to the process from gingivitis to periodontitis, peri-implant mucositis was regarded as the precursor for peri-implantitis (Jepsen et al., 2015). It should be noted that in spite of the reversibility of peri-implant mucositis, longer healing time compared to gingivitis was still required for complete disease resolution (Salvi et al., 2012). Furthermore, controlling or treating peri-implant lesions is regarded as unpredictable because of the susceptibility in peri-implant tissue by nature: parallel connective tissue fibers, stronger inflammatory response and unencapsulated inflammatory lesions (Tomasi et al., 2016).

It has been demonstrated that peri-implant health can be maintained through implant maintenance therapy (Salvi & Zitzmann, 2014). Although there were many terms to describe implant maintenance such as supportive peri-implant therapy (SPIT) (Monje et al., 2016), cumulative interceptive supportive therapy (CIST) (Lang et al., 2000), they are almost identical to the traditional supportive periodontal treatment (SPT), hence, the term SPT was adopted to describe the implant maintenance therapy in this study. In general, SPT includes clinical examination, radiographic evaluation, oral hygiene instructions, professional plaque control and mechanical debridement with different devices (Frisch, Ziebolz, Vach, & Ratka-Krüger, 2014).

Several systematic reviews have tried to correlate the importance of SPT with implant

survival rates, the prevalence of peri-implant diseases, implant bone loss and other clinical parameters (Hultin, Komiyama, & Klinge, 2007; Monje et al., 2016; Ramanauskaite & Tervonen, 2016; Salvi & Zitzmann, 2014). Aside from the participation of SPT, some other contributing factors could have influences on peri-implant conditions in terms of patient- or prosthetic-dependent indicators: smoking, biotype and overdenture designs (Berglundh, Persson, & Klinge, 2002).

SPT plays a critical role in maintaining the stability of periodontal status from the perspective of bacteria amount, clinical outcomes and further disease progression (Lang & Tonetti, 2003; Ramfjord, 1993). Nevertheless, the concept of preventive maintenance should also be advocated in dental implants in terms of bacterial patterns (Agerbaek, Lang, & Persson, 2006; Ziebolz, Schmalz, Gollasch, Eickholz, & Rinke, 2017), cost-effectiveness (Schwendicke, Tu, & Stolpe, 2015), biological complications (Berglundh et al., 2002; Salvi & Zitzmann, 2014), peri-implant tissue and survival rate (Goh & Lim, 2017), and the long-term stability of treated peri-implantitis (Roccuzzo, Layton, Roccuzzo, & Heitz-Mayfield, 2018).

Most of the previous reviews were focused only on the articles with SPT or did not conduct meta-analyses, the present paper carried out a comprehensive systematic review and meta-analysis on papers that had both patients with and without SPT. That is to say, the primary purpose of this paper was to extract the data from articles with both test and control groups for comparisons. In addition, the secondary purpose of the review was to find the correlation between certain factors (the interval for

maintenance, chemical agent application) and outcome of SPT.

MATERIAL AND METHODS

This systematic review and meta-analysis was reported in accordance with the 27-item PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement (Moher et al., 2009). Focused question was elaborated following the Population, Intervention, Comparison, and Outcome (PICO) criteria (Stone, 2002): "Do patients receiving SPT versus no SPT after implant placement have an improvement in implant survival rate and/or reduction in incidence of peri-implant disease?"

P: Systemically healthy subjects who received one or more dental implants; **I**: After implant restoration, patients received SPT, including a full mouth examination, oral hygiene reinforcement, and professional prophylaxis; **C**: After implant restoration, patients did not receive SPT to serve as the comparison; **O**: The primary outcome of this review was survival rate of implants, the prevalence of peri-implant mucositis and peri-implantitis at patient level. Additionally, secondary outcomes considered the significance of other confounding factors for primary results (SPT interval and the use of chemical agents, such as antibiotics or antiseptic agents).

Selection criteria

Eligible studies were included if they met the following inclusion criteria: 1. Any clinical studies, including prospective or retrospective, randomized or controlled clinical trials with SPT and non-SPT groups; 2. Any SPT should be mentioned with details in articles for maintenance care; 3. At least one-year follow-up period after

implant prosthesis loading; 4. Data of peri-implant conditions (either survival rate, bone level, plaque and bleeding status, or prevalence of peri-mucositis and/or peri-implantitis) are required.

Search strategy:

The search strategy was mainly conducted by means of three electronic databases - Pubmed/MEDLINE, EMBASE and Cochrane Central for articles published up to June 2018. The search terms used in Pubmed/MEDLINE for collecting articles were: ((((((((((maintenance[MeSH Terms]) OR supportive treatment[Title/Abstract]) OR supportive therapy[Title/Abstract]) OR supportive post-implant treatment[Title/Abstract])) OR cumulative interceptive supportive therapy[Title/Abstract])) OR prevention[MeSH Terms])) OR oral hygiene[MeSH Terms])) AND ((((dental implant[MeSH Terms]) OR implant[Title/Abstract])) OR implantation[Title/Abstract]). In EMBASE: ('maintenance therapy'/exp OR 'supportive therapy'/exp OR ('prevention'/exp AND 'control'/exp) OR 'mouth hygiene':ti,ab,kw) AND ('tooth implantation'/exp OR 'tooth implant'/exp OR 'implant':ti,ab,kw). In Cochrane database, “supportive treatment” and “dental implant” were used as title/abstract.

In addition, a manual search of relevant articles from January 2012 to June 2018 was conducted in the following journals: *Journal of Dental Research, Clinical Oral Implants Research, Journal of Clinical Periodontology, Journal of Periodontology, Clinical Implant Dentistry and Related Research, European Journal of Oral*

Implantology, *Journal of Oral and Maxillofacial Surgery, International Journal of Oral & Maxillofacial Implants, Implant Dentistry, International Journal of Periodontics* and *International of Periodontics and Restorative Dentistry, Journal of Oral Implantology*. Additionally, previous systematic reviews assessing maintenance therapy for the prevention of peri-implant diseases were also screened for article identification.

The articles derived from the search process were screened by two reviewers (CL and ZC) independently. Regarding selection criteria, titles and abstracts of search results were assessed, and then potential articles were evaluated in full text. κ value was calculated to assess the level of inter-reviewer agreement concerning study inclusion. Whenever there was a disagreement on selected studies, a decision was made after thorough discussion and consultation with a senior reviewer (HLW).

Risk of Bias Assessment

The quality assessment of selected non-randomized studies was evaluated for assessing the risk of bias with the Newcastle-Ottawa Scale (NOS) (Stang 2010). The included clinical trials would be rated as 0 to 8 stars from each parameter in Newcastle-Ottawa scale. (Department of Epidemiology and Community Medicine, 2013).

Data extraction and analyses

The data was extracted from the eligible articles by two independent reviewers (CL and ZC). Any inter-reviewer disagreement was resolved by discussion and consulted with another reviewer (HLW). If there was any doubt or missing data, the corresponding authors of potential literatures were contacted for clarification.

All statistical analyses were conducted using one statistical software program (Stata software, v14.0, StataCorp, College Station, TX). To standardize the reporting of our results, risk ratios (RRs) and 95% CI were calculated from the absolute number of events reported in each clinical trial; survival rates, the prevalence of peri-implant mucositis and peri-implantitis were analyzed at the patient level. Summary estimates of RR ratios were obtained with random-effects-models if heterogeneity across trials tested with the Q test ($p<0.10$) and I^2 statistics >75% proved to be high (Higgins & Thompson, 2002). By definition, weighted by the inverse variance method, RR>1 indicated a higher event rate of SPT group than the non- SPT group. Meta-regression analysis was performed to analyze the potential influence of confounding factors, including SPT interval, and use of chemical agents.

The possibility of publication bias (Supplementary Figure 1) was assessed with Harbord plot for dichotomous data, considering a significant publication bias if $P<0.05$ (Harbord et al. 2006).

RESULTS

Study selection

The whole literature screening process was presented in Figure 1. Initial screening yielded a total of 795 records from electronic search (Pubmed:487; EMBASE: 254; Cochrane: 54), and 22 records were found by hand-searching. After duplicates discarded, titles and abstracts revision, 16 articles were selected for full-text screening, and 7 of them were further excluded with reasons (Table 1) (Frisch et al., 2014; Henry, Bower, & Wall, 1995; Hultin, Gustafsson, & Klinge, 2000; Leonhardt, Gröndahl, Bergström, & Lekholm, 2002; Mir-Mari, Mir-Orfila, Figueiredo, Valmaseda-Castellón, & Gay-Escoda, 2012; Pjetursson et al., 2012; Telleman, Meijer, & Raghoebar, 2006). Finally, 9 eligible articles (Anner, Grossmann, Anner, & Levin, 2010; Aguirre-Zorzano, Vallejo-Aisa, & Estefanía-Fresco, 2013;Costa et al., 2012; Gay et al., 2016; Hoerler et al., 2017; Roccuzzo, Bonino, Aglietta, & Dalmasso, 2012; Roccuzzo, Bonino, Dalmasso, & Aglietta, 2014 ; M. Roccuzzo, De Angelis, Bonino, & Aglietta, 2010; Rinke, Ohl, Ziebolz, Lange, & Eickholz, 2011) were included in the systematic review. Except for one study (Roccuzzo et al., 2012) without available data, the remaining 8 articles were included in the quantitative synthesis. To evaluate the influence of SPT on SR, PI and MU, 6 (Aguirre-Zorzano et al., 2013; Anner et al., 2010; Gay et al., 2016; Roccuzzo et al., 2010; Roccuzzo et al., 2014) of 9, 3 (Aguirre-Zorzano et al., 2013; Costa et al., 2012; Rinke et al., 2011) of 9, and 3 (Aguirre-Zorzano et al., 2013; Costa et al., 2012; Rinke et al., 2011) of 9 articles were included in further meta-analysis respectively. The k value for inter-reviewer agreement for title/abstract and full-text screen was 0.87 and 0.91, respectively.

Description of studies

Main features of included studies were summarized with details, and articles with clinical variables were shown in terms of the differences in SPT and non- SPT (Table 2). First of all, five of the related articles were retrospective studies (Anner et al., 2010; Costa et al., 2012; Gay et al., 2016; Rinke et al., 2011; Hoerler et al., 2017) and four of them were prospective studies (Aguirre-Zorzano et al., 2013; Roccuzzo et al., 2012; Roccuzzo et al., 2014; Roccuzzo et al., 2010). Besides, some of the studies tried to add other confounding factors in comparison with SPT. For example, two articles from the same research group addressed attentions on different types of implant surfaces and even the severity of periodontitis of patients in 3 different groups (Roccuzzo et al., 2012; Roccuzzo et al., 2014). As for the content of maintenance care programs for dental implants, most of the studies focused on oral hygiene reinforcement and mechanical debridement with specific tools, including titanium, carbon-fiber or even steel curettes, scalers, ultrasonic devices with plastic tips, and rubber cup with paste. No matter which term they used for SPT, coronal prophylaxis and mechanical debridement were the main methods for implant maintenance. Only one study not only used above method but also air-polish kit and dental floss for their maintenance protocol (Gay et al., 2016). However, the necessity of using chemical agents for supportive treatment is controversial, with 3 out of 9 studies utilizing antibiotics, antiseptic agents or fluoride gel during the maintenance phase (Frisch, 2015; Rinke et al., 2011; Roccuzzo et al., 2012; Roccuzzo et al., 2014; Roccuzzo et al., 2010). The mean duration of follow-up ranged from 1 to 16 years. Furthermore, the interval of recall visits varied based on authors' preference such as

every 3 or 6 months or even tailored to each individual (Roccuzzo et al., 2012; Roccuzzo et al., 2014; Roccuzzo et al., 2010). Nonetheless, the SPT carried out in all selected papers should include full mouth examination and professional prophylaxis at least annually.

Risk of Bias and quality assessment

Among all included articles, there were 9 CCTs fulfilled the inclusion criteria. The risk of bias in 9 included CCTs were assessed and summarized (Supplementary Table 1), 4 of 9 articles were prospective studies (Aguirre-Zorzano et al., 2013; Roccuzzo et al., 2012; Roccuzzo et al., 2014; Roccuzzo et al., 2010). In summary, the assessment of all CCTs comprised 2 studies with less than 6 stars (Hoerler et al., 2017; Roccuzzo et al., 2012), 2 studies with 7 stars (Gay et al., 2016; Roccuzzo et al., 2012; Roccuzzo et al., 2014) and 5 studies with 8 stars (Aguirre-Zorzano et al., 2013; Anner et al., 2010; Costa et al., 2012; Rinke et al., 2011; Roccuzzo et al., 2010) according to all parameters in the criteria.

Primary outcomes (SPT and non-SPT)

Regarding the primary outcomes of SPT, the present review mainly emphasized either survival rate of dental implants or the percentage of peri-implant disease in both groups. Based on 6 included CCTs (Aguirre-Zorzano et al., 2013; Anner et al., 2010; Gay et al., 2016; Roccuzzo et al., 2010; Hoerler et al. 2017; Roccuzzo et al., 2014) in meta-analysis, SPT groups revealed significantly higher survival rate (RR:1.10; 95% CI: 1.07 to 1.14; $p< 0.001$) at patient level (Figure 2), with a moderate heterogeneity

(I^2=31.9 %, p=0.163). In two studies from the same group, all patients were divided into 3 groups based on different severity of chronic periodontitis, and the results showed stronger impacts on survival rate particularly in titanium-plasma-spray (TPS) surfaced implants and patients with chronic periodontitis (Roccuzzo et al., 2012; Roccuzzo et al., 2014). Except for one study with 1-year follow up time (Gay et al., 2016), the data were extracted from the studies with comparably long observation periods, to be more specific, from 30.5 months to 10 years. Additionally, meta-analysis was conducted in 3 studies (Aguirre-Zorzano et al., 2013; Costa et al., 2012; Rinke et al., 2011) for peri-implant disease assessment at patient level, and the results showed lower prevalence of peri-implant mucositis (RR:0.57; 95% CI: 0.43 to 0.76; p< 0.001) and peri-implantitis (RR:0.25; 95% CI: 0.13 to 0.48; p<0.001) in SPT groups with statistical significance (Figures 3 & 4). Among the 3 studies, the follow-up periods for observation ranged from 68.5 months to 5 years. The heterogeneity between studies was high for the prevalence of peri-mucositis (I^2=76.7%, p=0.014), and moderate for the prevalence of peri-implantitis (I^2=46.2%, p=0.156).

Secondary outcomes (correlating factors)

The confounding factors, including SPT interval, and use of chemical agent during SPT were analyzed by meta-regression. In survival rate, the P value of the meta-regression for the SPT interval was 0.324, for the use of chemical agent was 0.246, indicating the above factors did not significantly influence the outcome of analysis. Also, no significant influence was found among these factors for the

prevalence of peri-mucositis (p=0.324 and 0.462, respectively) and peri-implantitis (p=0.780 and 0.818, respectively).

Other clinical parameters

Aside from the survival rate and peri-implant disease around implants, several studies provided other clinical parameters for comparison, including peri-implant marginal bone loss, pocket depth, attachment loss, bleeding on probing, plaque index, plaque score, full mouth bleeding index, and plaque index (Table 2). Because of the difference in units and definition for each data, it was not possible to conduct a meta-analysis in present review. Nevertheless, in 5 CCTs (Aguirre-Zorzano et al., 2013; Costa et al., 2012; Roccuzzo et al., 2012; Roccuzzo et al., 2014; Roccuzzo et al., 2010), statistically higher incidence of bone loss, bleeding tendency and plaque accumulation could be found in non-SPT groups.

DISCUSSION

Our study found that different SPT treatment protocols were used across studies and it was impossible to identify a standard SPT protocol with specific instruments. In spite of the various terms of implant maintenance after placement, every program shared the similarity in part of components, including a review of dental and medical history, full mouth examination, improvement of oral hygiene and plaque removal procedure (Armitage & Xenoudi, 2016). Unlike the previous reviews, the present review divided the implant care into mechanical and chemical parts, and it showed large similarity in mechanical care even with different devices. Also, the present study was a pioneer in

making a comparison between SPT and non-SPT groups based on the outcomes in meta-analysis.

Primary outcomes

It has been shown that plaque control has been considered as one of the main triggers for peri-implant disease and even implant loss (Schou et al., 1992). SPT has been regarded as the first protective barrier to prevent from peri-implant disease progression (Hultin et al., 2007; Monje et al., 2016). A recent review further supports the importance of SPT after treatment of peri-implantitis (Roccuzzo et al., 2018). In accordance with the findings, the statistical analysis in present review revealed that SPT patients obtained higher survival rate and lower prevalence of peri-implant mucositis and peri-implantitis during long-term follow-up. Despite the uncertain causal relationship, SPT could be beneficial in enhancing peri-implant conditions in perspectives of better oral hygiene, plaque reduction and early detection of disease in initial stages.

According to the observation in the meta-analysis (Figure 2), the results possibly implied that SPT could play a more important role in certain circumstances: Titanium plasma surfaced implants in patients with a history of chronic periodontitis. To date, the history of periodontitis has been considered as one the most well-known risk indicators (Heitz-Mayfield, 2008). Even more, patients with generalized aggressive periodontitis were regarded as more susceptible to peri-implant diseases (Swierkot et al., 2012), and one cohort study showed more bone and attachment loss at implants even under periodic recall schedule for 10 years (Mengel, Behle, & Flores-de-Jacoby,

2007). Even though most articles still believed in the strong correlation between history of periodontitis and the development of peri-implantitis (Ferreira, Silva, Cortelli, Costa, & Costa, 2006; Monje et al., 2016), one retrospective study proposed that residual pockets rather than history of periodontitis could be the key factor of increased risk of peri-implantitis (Lee, Mattheos, Nixon, & Ivanovski, 2012). Likewise, even for treated implants, the importance of controlling residual pocket by means of SPT also was highlighted in a 5-year follow-up study (Serino, Turri, & Lang, 2015). In the present study, no statistical evidence could be addressed from the history of periodontitis with the participation in SPT. However, according to previous studies, residual pockets and non-SPT might be the more crucial factors to lower the survival rate of implants, and the statistical proof should be required by means of thorough investigation in related studies.

Secondary outcomes

Currently, there is no consensus on specific recall frequency for every patient, and an optimal recall interval may not be suitable for all cases. For natural dentition, a 5-year observation study showed shorter recall intervals could be more favorable in plaque reduction and help reduce bleeding tendency but not be additionally beneficial to other clinical parameters (Rosén et al., 1999). Furthermore, one systemic review failed to prove the necessity of fixed recall interval regimens within 3-6 months (Farooqi, Wehler, Gibson, Jurasic, & Jones, 2015). In harmony with the findings, one study obtained the results that frequency of visits could not have impacts on peri-implant health (Ferreira, Silva, Cortelli, Costa, & Costa, 2006). Based on Lang's

CIST program for implant care, all treatment protocols must depend on the need and diagnosis of peri-implant tissue; however, specific interval time was not mentioned as a reference (Lang et al., 2000). On the contrary, a minimal recall interval of 5 to 6 months was suggested (Monje et al., 2016). In the present review, a specific time point for recall interval could not be obtained after statistical investigation, and the outcome could attribute to different and uncontrolled susceptibility to peri-implant diseases.

Considering the heterogeneity in maintenance strategies, plaque removal can be simply divided into chemical and mechanical approaches. The need of using chemical agents remains controversial. In Lang's CIST regimen, either chlorhexidine alone or combined with antibiotics could be considered in situations of suppuration with bleeding and pocket depth of more than 5 mm (Lang et al., 2000). Conversely, one randomized clinical trial showed the supplemental application of chlorhexidine vanish had no significant additional benefits comparing to other mechanical methods alone (Ziebolz, Klipp, et al., 2017). Based on one review with meta-analysis, adjunctive therapy with chemical agents could not improve the clinical outcomes achieved by mechanical debridement (Schwarz et al., 2015). Tracing back to present review, no better outcomes could be obtained with additional chemical agents, which implies that antibiotics or antiseptic agents' application during SPT may not be needed. In summary, data from this study implies that any form of SPT is better than nothing in terms of increasing implant survival and preventing peri-implantitis incidence."

Limitations

The limitations of this review should be highlighted as below. First, all included articles in present review were not RCT but CCTs or even cohort studies, which could inevitably weaken the quality of studies. For this reason, only limited articles could be included for meta-analysis. Nevertheless, out of respect of ethical issues, it was not possible to set up a well-designed RCT with patients intentionally exclude from SPT program as the control group. Second, the complete data for primary outcomes could merely be extracted at the patient level, and some deviation could also be found from patient- or implant-based records. To eliminate the bias, the number of included articles in the meta-analysis would be consequently reduced. Apart from the heterogeneity in primary outcomes, particularly with vague descriptions of the content of SPT and the diverse follow-up period, there was no consistent way to represent bone loss, plaque accumulation and bleeding tendency units. Hence, the meta-analysis in the present review could not be conducted in clinical parameters. In addition, multiple factors could be responsible for the peri-implant disease, and none of the include articles could comprehensively be ruled out all possible factors for each patient, such as implant surface, implant locations, implant-supported prosthesis design, smoking habits and patient-based potential systematic disease. Last but not least, the present review includes only English language publications, which may count for selection bias. Additionally, the protocol has not been registered in the clinical trial web portal. With the limitation of this review, all results should be interpreted with caution.

Summary from the review

Despite the limitations mentioned in the review, the results still reveal insight into the clinical implications after implant placement.

1. Provision of maintenance care is better than not providing maintenance care. The results indicated positive impacts of SPT for implant maintenance compared to non-SPT groups.
2. A minimum common protocol of SPT should include full mouth examination and professional prophylaxis (oral hygiene instructions, plaque control and mechanical instrumentation) at least annually.
3. The evidence of other factors about SPT, such as chemical agent application and recall intervals, was inconclusive.

CONCLUSION

With the limitations of this review, SPT can potentially improve peri-implant health in terms of implant survival rate, prevent peri-implant mucositis, and peri-implantitis. Additionally, the correlation in recall interval and adjunctive use of chemical agents during SPT to implant survival rate and incidence of peri-implant mucositis and peri-implantitis could not be found in the present review. In the future, more well-controlled studies with consistent and complete data are required for investigating the efficacy of SPT.

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Table 1. Excluded articles with reasons.

Author (Year)	**Excluded articles with reasons**
Henry 1995	No exact numbers for post- implant outcomes.
Hultin 2000	No details for implant maintenance care.
Leonhardt 2002	No details for implant maintenance care.
Telleman 2006	No details for implant maintenance care.
Pjetursson 2012	No details for implant maintenance care.
Mir- Mari 2012	No details for implant maintenance care.
Frisch 2014	No exact numbers for post- implant outcomes.

Table 2. Included articles with supportive treatment (SPT) and without supportive treatment (non- SPT) groups.

Author / year	**Study Type (R or P)**	**Chemical (F, AS, AB or N)**	**Mechanical (OHI, Int, S)**	**Interval**	**Average FU duration (M or Y)**	**Loss FU at the end**	**Test SPT (Pt N)**	**Survival N (%)**	**PIMS N(%)**	**PIS N(%)**	**Others** BL:N(%), BoP, PI, FMPS, FMBS: %	**Control Non-SPT (Pt N)**	**Survival N (%)**	**PIMS N(%)**	**PIS N(%)**	**Others** BL:N(%), BoP, PI, FMPS, FMBS: %
Anner 2010	R	NR	NR	Annual	30.8M	NR	P:246 I:873	P:225(91.5) I: 845(96.8)	NR	NR	NR	P:229 I:753	P:192(83.8) I: 704(93.5)	NR	NR	NR
Roccuzzo 2010 (HP)	Pr	AS, AB	OHI, Int, S	Tailored	10Y	P: 11 I: 18	P:24	P:22(91.7)	NR	NR	BL>3mm: 2(8.3)	P:4	P:4(100)	NR	NR	BL>3mm: 0(0)
Roccuzzo 2010 (ModP)	Pr	AS, AB	OHI, Int, S	Tailored	10Y		P:26	P:25(96.2)	NR	NR	BL>3mm: 3(11.5)	P:11	P:6(54.5)	NR	NR	BL>3mm: 7(63.6)
Roccuzzo 2010 (SevP)	Pr	AS, AB	OHI, Int, S	Tailored	10Y		P:29	P:26(89.7)	NR	NR	BL>3mm: 7(24.1)	P:7	P:3(42.9)	NR	NR	BL>3mm: 4(57.1)

Rinke 2011	R	F	OHI, Int	3-6 M	68.2M	NR	P:58	NR	P:17(29.3)	P:1(1.7)	NR	P:31	NR	P:23(74.2)	P:9(29.3)	NR
Costa 2012	R	NR	OHI, Int,	Annual	5Y	NR	P:39	NR	P:20(51.5)	P:7(18)	BoP: 41.7→33.3	P:41	NR	P:23(56.1)	P:18(43.9)	BoP: 50.2→62.7
Roccuzzo 2012 (HP)	Pr	AS, AB	OHI, Int, S	Tailored	10Y	P: 11 I: 18	24	NR	NR	NR	PI:17.2	4	NR	NR	NR	PI:11.4

(Continued)

Author / year	Study type	Chemical	Mechanical	Interval	Average FU duration (M, Y)	Loss FU at the end	Test SPT (N)	Survival N (%)	PIMS (N/%)	PIS (N/%)	Others	Control Non-SPT (Pt N)	Survival (N/%)	PIMS (N/%)	PIS (N/%)	Others
Roccuzzo 2012(ModP)	Pr	AS, AB	OHI, Int, S	Tailored	10Y	P: 11 I: 18	26	NR	NR	NR	PI:25	11	NR	NR	NR	PI:38.5
Roccuzzo 2012(SevP)	Pr	AS, AB	OHI, Int, S	Tailored	10Y		29	NR	NR	NR	PI:20.3	7	NR	NR	NR	PI:39.6

Aguirre-Zorzano 2013 (P)	Pr	NR	OHI, Int Occlusion check	4M	4Y	NR	P:27 I:123	P:27(100) I:123(100)	P:5(18.5)	P:1(3.7)	PI:20.34	P:22 I:123	P:21(95.5) I:122(99.2)	P:11(50)	P:5(22.7)	PI:59.63
Roccuzzo 2014(HP)	Pr	AS, AB	OHI, Int, S	Tailored	10Y	P: 11 I: 18	P:19 I:32	P:19(100)	NR	NR	FMPS: 27.6→19 FMBS: 23.4→15.8	P:13 I:54	P:13(100)	NR	NR	FMPS: 31.1→26.5 FMBS: 27.5→22.2
Roccuzzo 2014(ModP)	Pr	AS, AB	OHI, Int, S	Tailored	10Y		P:25 I:52	P:25 (100)	NR	NR	FMPS: 34→23.4 FMBS: 30.4→20.1	P:21 I:96	P:19(93.2)	NR	NR	FMPS: 42.6→32.7 FMBS: 44.5→31.2

(Continued)

Author / year	Study type	Chemical	Mechanical	Interval	Average FU duration (M, Y)	Loss FU at the end	Test SPT (N)	Survival N (%)	PIMS (N/%)	PIS (N/%)	Others	Control Non-SPT (Pt N)	Survival (N/%)	PIMS (N/%)	PIS (N/%)	Others
Roccuzzo 2014(SevP)	Pr	AS, AB	OHI, Int, S	Tailored	10Y	P: 11 I: 18	P:31 I:72	P: 30 (98.6)	NR	NR	FMPS: 47.4→22.9 FMBS: 45.6→20.3	P:14 I:102	P:13(93.3)	NR	NR	FMPS: 60.7→46.9 FMBS: 56.2→43.2
Gay 2016	R	NR	OHI, Int	Annual	1Y	NR	P:247	P:241(97.6)	NR	NR	NR	P:627	P:79(87.4)	NR	NR	NR
Hoerler 2017 (All edentulous arch)	R	NR	Int	<6M	20Y	Test:P:6 Control: P:8	P:49 I:332	P: 43(87.8)	NR	NR	SR free of soft tissue pathology: 14(75)	P:100 I: 609	P: 91(91)	NR	NR	SR free of soft tissue pathology: 18(87)

R: retrospective; Pr: prospective; F: fluoride gel; AS: antiseptic agents; AB:antibiotics; N:none; NR: no records; Int: instrumentation; S:surgery; M: months; N: numbers; PIMS: peri-implant mucositis; PIS: peri-implantitis; BL: bone loss; BoP: bleeding on probing; PI:plaque index; FMPS: full mouth plaque score; FMBS: full mouth bleeding score; FU: follow-up; P: patient; I: implant.

Figure legends

Fig 1. The screening process.

Fig 2. Meta-analysis was conducted in assessing survival rate (SR) between supportive post-implant treatment (SPT) and non- SPT groups. TPS: titanium-plasma-spray implant; SLA: sandblasted and acid-etched implants.

Fig 3. Meta-analysis was performed to examine the prevalence of peri-implant mucositis in SPT and non- SPT groups.

Fig 4. Meta-analysis was performed to examine the prevalence of peri-implantitis in SPT and non- SPT groups.

Table 1. Excluded articles with reasons.

Author (Year)	**Excluded articles with reasons**
Henry 1995	No exact numbers for post- implant outcomes.
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Leonhardt 2002	No details for implant maintenance care.
Telleman 2006	No details for implant maintenance care.
Pjetursson 2012	No details for implant maintenance care.
Mir- Mari 2012	No details for implant maintenance care.
Frisch 2014	No exact numbers for post- implant outcomes.

Table 2. Included articles with with supportive post-implant treatment (SPIT) and without supportive post-implant treatment(non-SPIT) groups.

Author / year	**Study Type (R or P)**	**Chemical (F, AS, AB or N)**	**Mechanical (OHI, Int, S)**	**Interval**	**Average FU duration (M or Y)**	**Loss FU at the end**	**Test SPIT (Pt N)**	**Survival N (%)**	**PIMS N(%)**	**PIS N(%)**	**Others** BL:N(%), BoP, PI, FMPS, FMBS: %	**Control Non-SPIT (Pt N)**	**Survival N (%)**	**PIMS N(%)**	**PIS N(%)**	**Others** BL:N(%), BoP, PI, FMPS, FMBS: %
Anner 2010	R	NR	NR	Annual	30.8M	NR	P:246 I:873	P:225(91.5) I: 845(96.8)	NR	NR	NR	P:229 I:753	P:192(83.8) I: 704(93.5)	NR	NR	NR
Roccuzzo 2010 (HP)	Pr	AS, AB	OHI, Int, S	Tailored	10Y	P: 11 I: 18	P:24	P:22(91.7)	NR	NR	BL>3mm: 2(8.3)	P:4	P:4(100)	NR	NR	BL>3mm: 0(0)
Roccuzzo 2010 (ModP)	Pr	AS, AB	OHI, Int, S	Tailored	10Y		P:26	P:25(96.2)	NR	NR	BL>3mm: 3(11.5)	P:11	P:6(54.5)	NR	NR	BL>3mm: 7(63.6)
Roccuzzo	Pr	AS, AB	OHI, Int, S	Tailored	10Y		P:29	P:26(89.7)	NR	NR	BL>3mm:	P:7	P:3(42.9)	NR	NR	BL>3mm:

2010 (SevP)											7(24.1)				4(57.1)
Rinke 2011	R	F	OHI, Int	3-6 M	68.2M	NR	P:58	NR	P:17(29.3)	P:1(1.7)	NR	P:31	NR	P:23(74.2)	P:9(29.3)	NR
Costa 2012	Rr	NR	OHI, Int,	Annual	5Y	NR	P:39	NR	P:20(51.5)	P:7(18)	BoP: 41.7→33.3	P:41	NR	P:23(56.1)	P:18(43.9)	BoP: 50.2→62.7
Roccuzzo 2012 (HP)	Pr	AS, AB	OHI, Int, S	Tailored	10Y	P: 11 I: 18	24	NR	NR	NR	PI:17.2	4	NR	NR	NR	PI:11.4

(Continued)

Author / year	**Study type**	**Chemical**	**Mechanical**	**Interval**	**Average FU duration (M, Y)**	**Loss FU at the end**	**Test SPIT (N)**	**Survival N (%)**	**PIMS (N/%)**	**PIS (N/%)**	**Others**	**Control Non-SPIT (Pt N)**	**Survival (N/%)**	**PIMS (N/%)**	**PIS (N/%)**	**Others**

Roccuzzo 2012(ModP)	Pr	AS, AB	OHI, Int, S	Tailored	10Y	P: 11 I: 18	26	NR	NR	NR	PI:25	11	NR	NR	NR	PI:38.5
Roccuzzo 2012(SevP)	Pr	AS, AB	OHI, Int, S	Tailored	10Y		29	NR	NR	NR	PI:20.3	7	NR	NR	NR	PI:39.6
Aguirre-Zorzano 2013 (P)	Pr	NR	OHI, Int Occlusion check	4M	4Y	NR	P:27 I:123	P:27(100) I:123(100)	P:5(18.5)	P:1(3.7)	PI:20.34	P:22 I:123	P:21(95.5) I:122(99.2)	P:11(50)	P:5(22.7)	PI:59.63
Roccuzzo 2014(HP)	Pr	AS, AB	OHI, Int, S	Tailored	10Y	P: 11 I: 18	P:19 I:32	P:19(100)	NR	NR	FMPS: 27.6→19 FMBS: 23.4→15.8	P:13 I:54	P:13(100)	NR	NR	FMPS: 31.1→26.5 FMBS: 27.5→22.2
Roccuzzo 2014(ModP)	Pr	AS, AB	OHI, Int, S	Tailored	10Y		P:25 I:52	P:25 (100)	NR	NR	FMPS: 34→23.4 FMBS:	P:21 I:96	P:19(93.2)	NR	NR	FMPS: 42.6→32.7 FMBS:

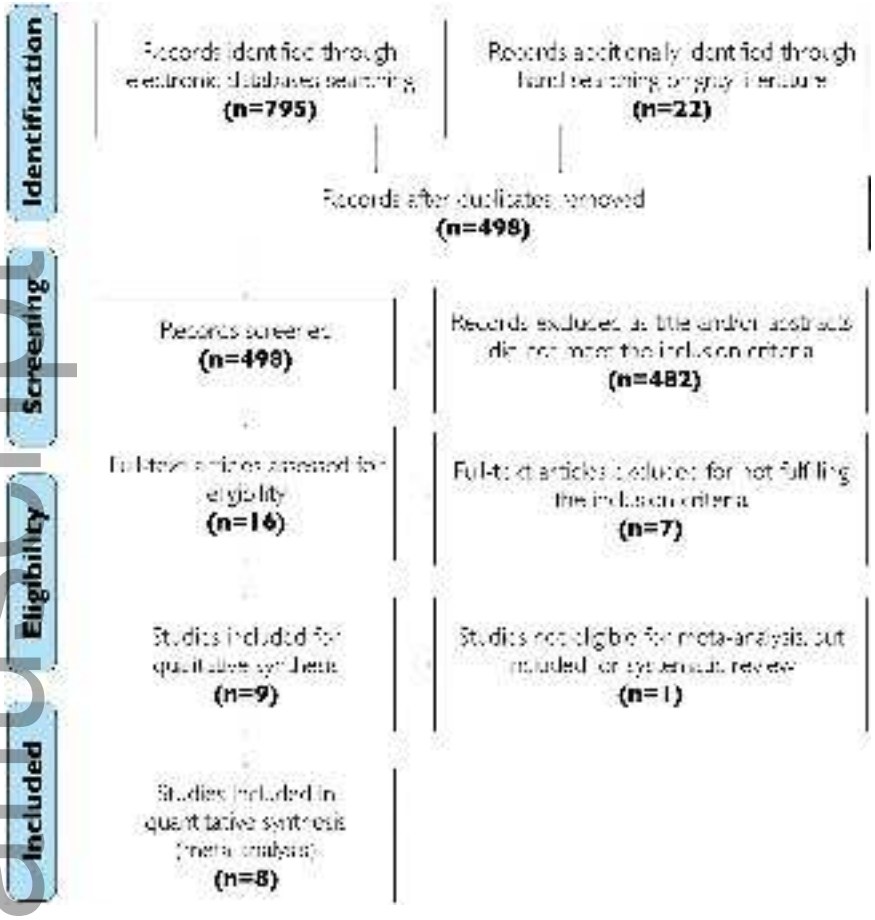
											30.4→20.1					44.5→31.2

Author / year	**Study type**	**Chemical**	**Mechanical**	**Interval**	**Average FU duration (M, Y)**	**Loss FU at the end**	**Test SPIT (N)**	**Survival N (%)**	**PIMS (N/%)**	**PIS (N/%)**	**Others**	**Control Non-SPIT (Pt N)**	**Survival (N/%)**	**PIMS (N/%)**	**PIS (N/%)**	**Others**
Roccuzzo 2014(SevP)	Pr	AS, AB	OHI, Int, S	Tailored	10Y	P: 11 I: 18	P:31 I:72	P: 30 (98.6)	NR	NR	FMPS: 47.4→22.9 FMBS: 45.6→20.3	P:14 I:102	P:13(93.3)	NR	NR	FMPS: 60.7→46.9 FMBS: 56.2→43.2
Gay 2016	R	NR	OHI, Int	Annual	1Y	NR	P:247	P:241(97.6)	NR	NR	NR	P:627	P:79(87.4)	NR	NR	NR
Hoerler 2017 (All edentulous arch)	R	NR	Int	<6M	20Y	Test:P:6 Control: P:8	P:49 I:332	P: 43(87.8)	NR	NR	SR free of soft tissue pathology:	P:100 I: 609	P: 91(91)	NR	NR	SR free of soft tissue pathology:

											14(75)					18(87)

(Continued)

R: retrospective; Pr: prospective; F: fluoride gel; AS: antiseptic agents; AB:antibiotics; N:none; NR: no records; Int: instrumentation; S:surgery; M: months; N: numbers; PIMS: peri-implant mucositis; PIS: peri-implantitis; BL: bone loss; BoP: bleeding on probing; PI:plaque index; FMPS: full mouth plaque score; FMBS: full mouth bleeding score; FU: follow-up; P: patient; I: implant



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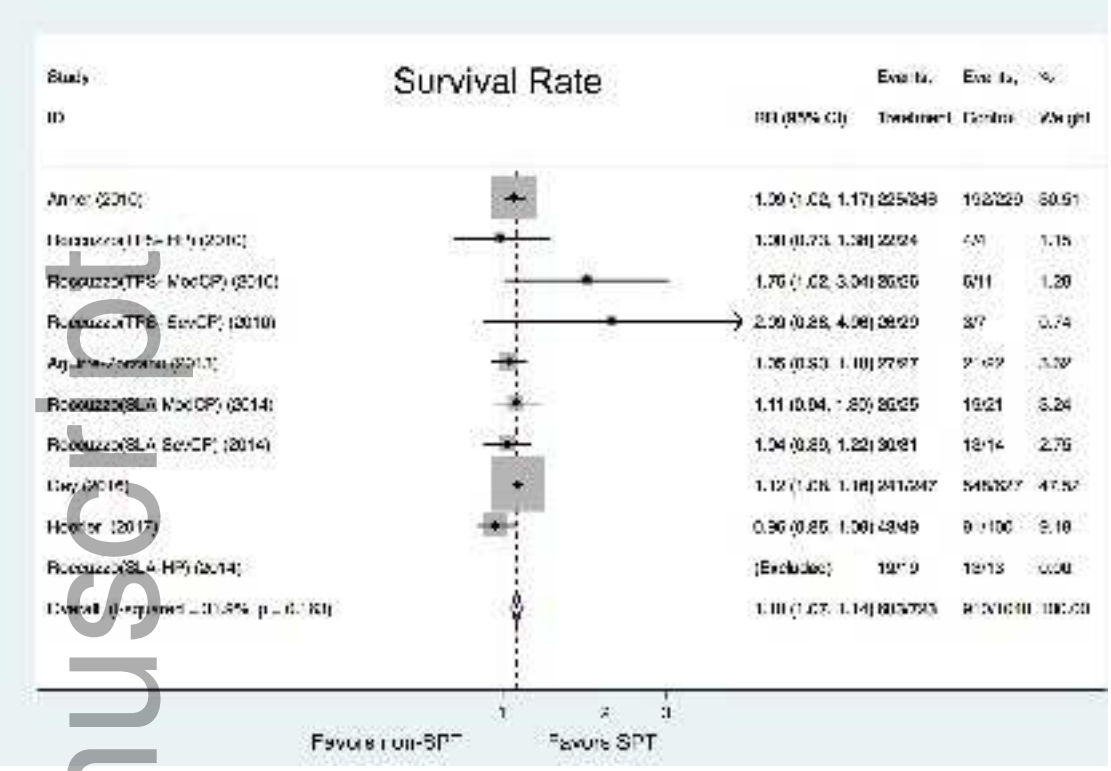

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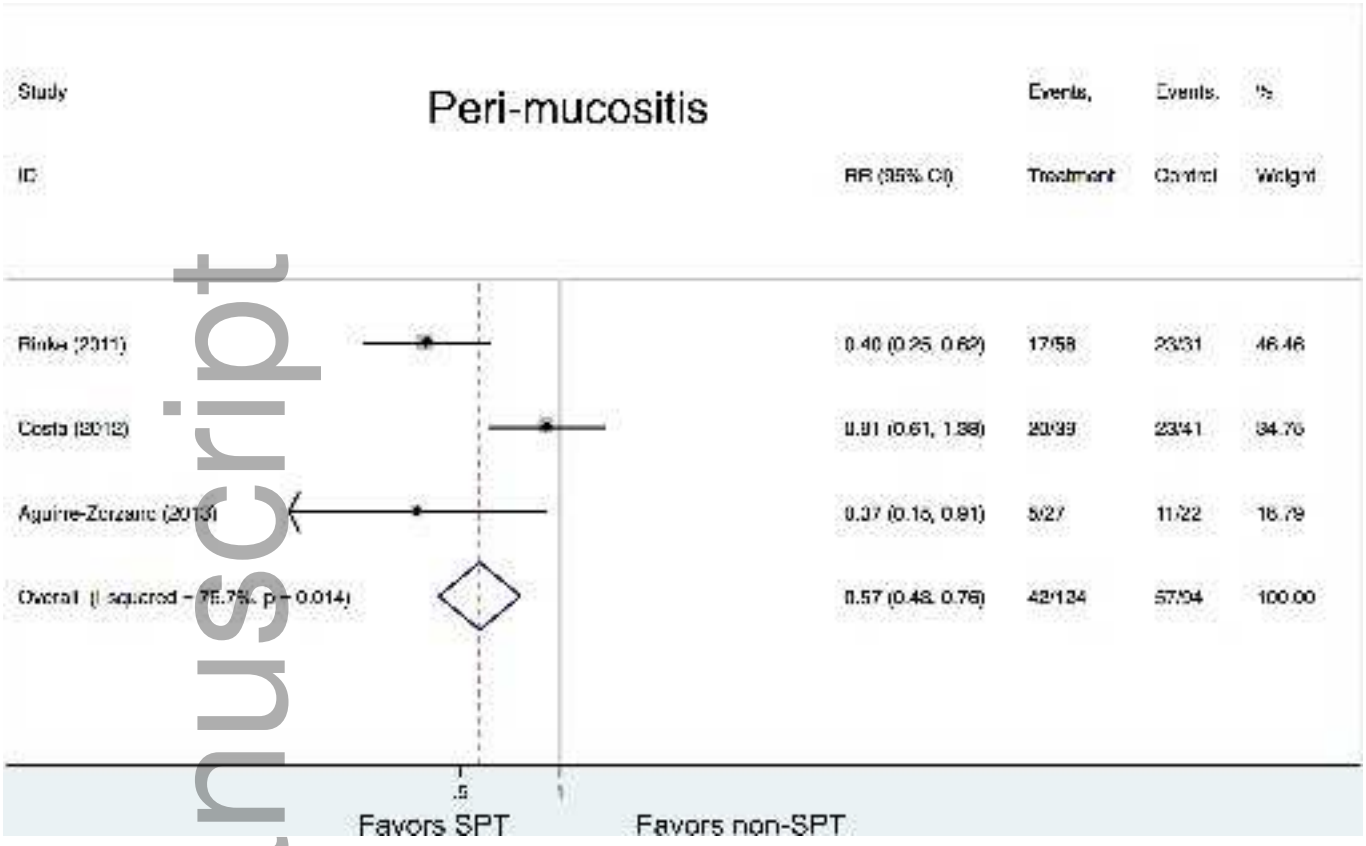

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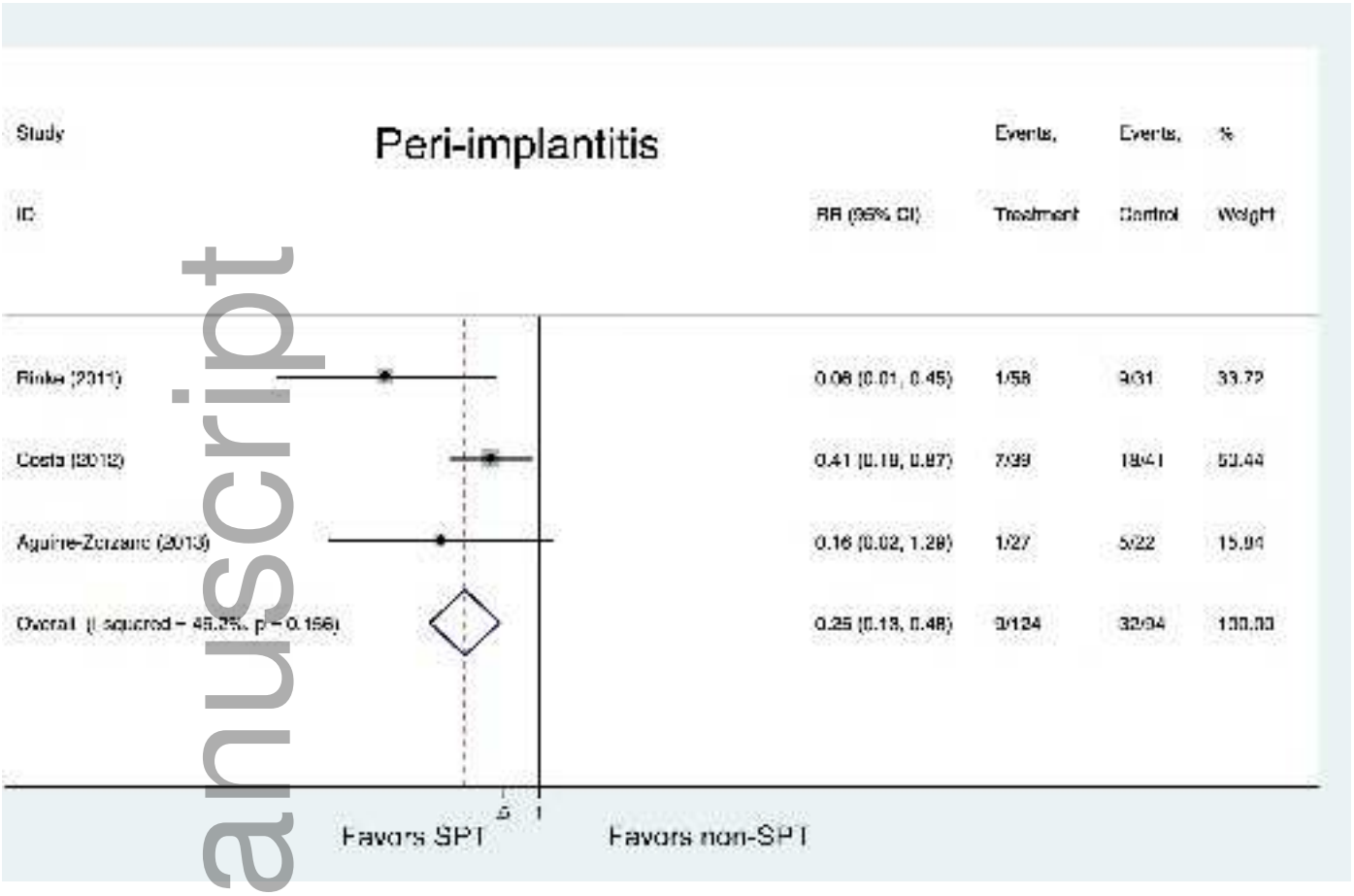

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