The Effects of Patient Compliance in Supportive Periodontal Therapy on Tooth Loss: A systematic Review and Meta-analysis

Isabelle Schalch de Oliveira Campos,[1] Maiara Rodrigues de Freitas,[1] Fernando O Costa,[2] Sheila Cavalca Cortelli,[1] Emanuel Silva Rovai[1] and José R Cortelli[1]

[1]Department of Dentistry, Periodontics Research Division, University of Taubaté, Taubaté, São Paulo, Brazil.
[2]School of Dentistry, Department of Periodontology, Federal University of Minas Gerais, Brazil

Abstract

Background: The present review aimed to assess the impact of being a complier to supportive periodontal therapy (SPT), when compared to not being a complier, on tooth loss in patients with periodontitis.

Materials and Methods: Prospective and retrospective observational studies were included. MEDLINE, EMBASE, and LILACS databases were searched up to May 2019. The odds-ratio (OR) and standard error (SE) values of the studied groups (compliant or non-compliant) were converted to logOR, and the results of individual studies were grouped using a random effects model.

Results: From a total of 1815 articles initially searched, 13 retrospective studies and one prospective study comparing tooth loss of complier and non-complier individuals in SPT were included. Meta-analysis of eight studies showed that non-compliers in SPT have an increased risk of tooth loss when compared with compliers. Overall meta-analysis demonstrated that non-compliant patients in SPT have a 26% increased risk of tooth loss when compared with compliant patients (OR = 1.26; 95% CI = 1.06 to 1.51, Heterogeneity: I2 = 0%, p = 0.008).

Conclusion: Patients with periodontitis who do not comply in SPT have a higher risk of tooth loss than compliant patients. Oral health professionals should implement measures to obtain optimal adherence by patients in SPT.

Keywords: Tooth loss, maintenance therapy, periodontal disease, systematic review.

Introduction

Periodontitis is a prevalent chronic disease that results in the destruction of tooth support tissues, representing one of the main causes of tooth loss in adults (Burt 2005; Eke *et al*., 2016; Papapanou *et al*., 2018). Besides masticatory dysfunction, tooth loss due to periodontitis has been associated with impaired self-esteem, esthetics, social interaction, and quality of life (Steele *et al*., 2004; Hung *et al*., 2005; Mack *et al*., 2005; Cunha-Cruz *et al*., 2007; Llanos *et al*. 2018; Anbarserri *et al*., 2020).

Correspondence to: Emanuel Silva Rovai, Department of Dentistry, Periodontics Research Division, University of Taubaté, Taubaté, São Paulo, Brazil.
E-mail: emanuel.rovai@hotmail.com

Periodontal treatment is basically divided into two treatments: active periodontal therapy (APT), which aims to control of the inflammatory process through the mechanical removal of the subgingival biofilm and the establishment of a favorable environment for periodontal tissue health (Cobb, 2002; Heitz-Mayfield and Lang, 2013); and supportive periodontal therapy (SPT), which aims for long term maintenance of periodontal health achieved by APT, preventing disease recurrence and progression and minimizing tooth loss (Renvert and Persson, 2004; Graetz *et al*., 2020).

SPT consists of recalls according to the individual's risk, professional plaque control, and oral hygiene reorientation and motivation (Axelsson and Lindhe, 1981; Manresa *et al*., 2018). Results have demonstrated

that patients who adhere to the proposed SPT usually maintain periodontal disease stability and a very low rate of bone and tooth loss over the years (Axelsson and Lindhe, 1981; Becker *et al.*, 1984a; Becker *et al.*, 1984b; Wilson *et al.*, 1987; Axelsson *et al.*, 2004; De Wet *et al.*, 2018; Graetz *et al.*, 2020). However, despite the above-mentioned benefits, studies have shown that the number of patients in private and public clinics who regularly attend SPT can be low (Wilson *et al.*, 1984; Checchi *et al.*, 1994; Demetriou *et al.*, 1995; Soolari and Rokn , 2003; Lorentz *et al.*, 2009).

Unlike SPT compliant patients, non-compliant patients have a high recurrence of periodontal disease, demonstrating an increase in plaque index, bleeding on probing, probing depth, attachment loss, and tooth loss (Matuliene *et al.*, 2010; Costa *et al.*, 2015; Costa *et al.*, 2018). In addition, periodontal parameters practically return to the same levels seen before treatment in patients who undergo APT and do not return for SPT, demonstrating that APT without SPT may have little value for the patient (Becker *et al.*, 1984a).

Although there are other systematic reviews on this topic (Lee *et al.* 2015, Manresa *et al.* 2018), the review conducted by Lee *et al.* (2015), was carried out more than 5 years ago, and since then, studies with longer follow up have been published (Costa *et al.* 2018), and unlike our study, the review conducted by Manresa *et al.* (2018) included only randomized clinical trials, concluding that there are no randomized clinical trials that evaluate tooth loss on this topic. Therefore, the aim of this systematic review (SR) is to assess the impact of being complier to SPT, compared to not being complier, on tooth loss in patients with periodontitis. The following focused question was addressed: "In patients with periodontitis, do non-compliers to SPT have higher risk of tooth loss when compared with compliers?"

Material and Methods

This systematic review followed the preferred reporting items for systematic reviews and meta-analysis (PRISMA) and meta-analysis of observational studies (MOOSE). The protocol has been registered in the International Prospective Register of Systematic Reviews (CRD ID: 148862).

Eligibility criteria

Only observational (retrospective and prospective) studies were included using the following requirements: a) original studies published in English; b) data provided the period of follow-up of periodontal maintenance therapy; c) data comparing compliance and noncompliance in SPT; d) outcome data of tooth loss; and e) studies with at least a five-year follow-up period.

The focus question was developed using the PICOS/PECOS (patient (P), exposure (E), comparison (C), outcome (O), and study (S) framework: periodontitis patients (P), not being complier of SPT (E), complier of SPT (C), tooth loss (O), and prospective and retrospective observational studies (S).

Narrative analyses, case series, reported cases, in vitro, and animal studies were excluded. Studies that did not include two groups (compliant and non-compliant patients), evaluate follow-up times, and present data on tooth loss were also excluded.

Search strategy

An electronic literature search was performed on the MEDLINE, EMBASE and LILACs databases up to May 2019 (Table 1). The following search strategy was used: (((Periodontitis OR periodontal disease)) AND (Maintenance or preventive maintenance therapy OR periodontal maintenance therapy or compliance or supportive periodontal care or supportive periodontal

Table 1. Search strategy in Databases.

DATABASE	SEARCH STRATEGY	Number of studies identified
MEDLINE	(((periodontitis OR periodontal disease)) AND (maintenance OR prevention maintenance therapy OR periodontal maintenance therapy OR compliance OR supportive periodontal care OR supportive periodontal therapy OR supportive periodontal treatment)) AND (tooth loss OR bone loss OR attachment loss)	1409
LILACS	(((periodontitis OR periodontal disease)) AND (maintenance OR prevention maintenance therapy OR periodontal maintenance therapy OR compliance OR supportive periodontal care OR supportive periodontal therapy OR supportive periodontal treatment)) AND (tooth loss OR bone loss OR attachment loss)	15
EMBASE	(((periodontitis OR periodontal disease)) AND (maintenance OR prevention maintenance therapy OR periodontal maintenance therapy OR compliance OR supportive periodontal care OR supportive periodontal therapy OR supportive periodontal treatment)) AND (tooth loss OR bone loss OR attachment loss)	391

therapy OR supportive periodontal treatment)) AND (Tooth loss or bone loss or attachment loss). We also conducted a manual search using the reference lists of the selected articles.

In the first phase, two reviewers (ISOC and MRF) selected independent titles and abstracts obtained by the search strategy. Their disagreements were resolved by the decisions of a third reviewer (ESR). In the second phase, they reviewed the full texts that met the inclusion requirements or those with unclear information in the title and abstract. The reasons the studies were rejected were recorded for each report.

Data extraction

The following items were extracted from publications that met the inclusion criteria: author, year, country, study design, sample size, periodontal maintenance follow-up, total and group tooth loss, results, conflicts of interest, and source of financing.

Risk of bias

To assess the risk of bias in retrospective and prospective studies, a modified version of the Newcastle-Ottawa Scale (NOS) was used (Sendyk *et al*., 2017). NOS was adapted with seven questions for the retrospective studies and ten questions for the prospective study, assessing sample size calculation, representativeness of the compliant patients, selection of the non-compliant patients, ascertainment of regular patients, demonstration that outcomes of interest were not present at start of studies, training/calibration of assessors of clinical outcomes, clear descriptions of inclusion/exclusion criteria, comparability, outcomes, and statistics.

In the retrospective studies, the scores ranged from 0 to 10. Studies with 7 to 10 stars were arbitrarily rated as low risk of bias, 5 to 6 stars as moderate risk of bias and < 5 stars as high risk of bias. For prospective studies, scores ranged from 0 to 11 stars. Studies with 9 to 11 stars were arbitrarily rated as low risk of bias, 6 to 8 stars as moderate risk of bias, and < 6 stars as high risk of bias.

The same reviewers (ISOC and MRF) analyzed the studies independently, and any disagreement between them was resolved by adjudication via consultation with the third reviewer (ESR).

Summary measures and synthesis of results

Studies that presented the number of teeth lost in compliant and non-compliant patients to SPT or the odds ratio (OR) for tooth loss were included in meta-analysis. Studies were excluded from meta-analysis if they showed only the proportion of patients experiencing tooth loss, mean number of teeth lost per patient, or percent of teeth lost. Analyses were performed using a software package (Review Manager software, version 5.3, The Nordic Cochrane Center, The Cochrane Collaboration, Copenhagen, Denmark). OR and standard error (SE) values of the studied groups (compliant and non-compliant) were converted to logOR and the results of individual studies were grouped using a random effects model. The meta-analysis used the inverse variation method and the DerSimonian-Laird estimator for Tau (Axelsson and Lindhe, 1981). The pooled results were estimated using OR and 95% confidence interval (CI). Since only one prospective study was included in the present systematic review, meta-analysis was conducted only for retrospective studies. Statistical heterogeneity among studies was assessed with the Cochrane Q test and I^2.

Results

Search results

Search strategies in electronic databases and manual searches resulted in identification of a total of 1815 articles, 1794 were excluded after the review of titles and abstract. In the second phase, 21 articles were selected for full text reading (Kocher *et al*., 2000; Checchi *et al*., 2002; Miyamoto *et al*., 2006; Eickholz *et al*., 2008; Pretzl *et al*., 2009; Tsami *et al*., 2009; Matuliene *et al*., 2010; Miyamoto *et al*., 2010; Baumer *et al*., 2011; Ng *et al*., 2011; Costa *et al*., 2014; Kim *et al*., 2014; Seirafi *et al*., 2014; Costa *et al*., 2015; Graetz *et al*., 2015; Díaz-Faes *et al*., 2016; Yoshino *et al*., 2016; Graetz *et al*., 2017; Stadler *et al*., 2017; Costa *et al*., 2018; Petit *et al*., 2019). Seven were excluded for the following reasons: Costa *et al*. (2014; Costa *et al.,* 2015) used the same population as Costa *et al*. (2018); Graetz *et al*. (2015; 2017) did not have sufficient information; Miyamoto *et al*. (2006) used the same population of Miyamoto *et al*. (2010); Pretzl *et al*. (2008) used the same population of Eickholz *et al*. (2008); in Yoshino *et al*. (2016), the subject population was not composed of patients with periodontitis. A total of 14 articles (Kocher *et al*., 2000; Checchi *et al*., 2002; Stadler *et al*., 2017; Eickholz *et al*., 2008; Tsami *et al*., 2009; Matuliene *et al*., 2010; Miyamoto *et al*., 2010; Baumer *et al*., 2011; Ng *et al*., 2011; Kim *et al*., 2014; Seirafi *et al*., 2014; Díaz-Faes *et al*., 2016; Costa *et al*., 2018; Petit *et al*., 2019) were included in this review. It was possible to include 8 of these (Kocher *et al*., 2000; Checchi *et al*., 2002; Eickholz *et al*., 2008; Matuliene *et al*., 2010; Miyamoto *et al*., 2010; Ng *et al*., 2011; Kim *et al*., 2014; Seirafi *et al*., 2014) in the meta-analysis (Figure 1).

Included studies

Retrospective studies

Thirteen retrospective studies were included (Kocher *et al*., 2000; Checchi *et al*., 2002; Stadler *et al*., 2017; Eickholz *et al*., 2008; Tsami *et al*., 2009; Matuliene *et al*.,

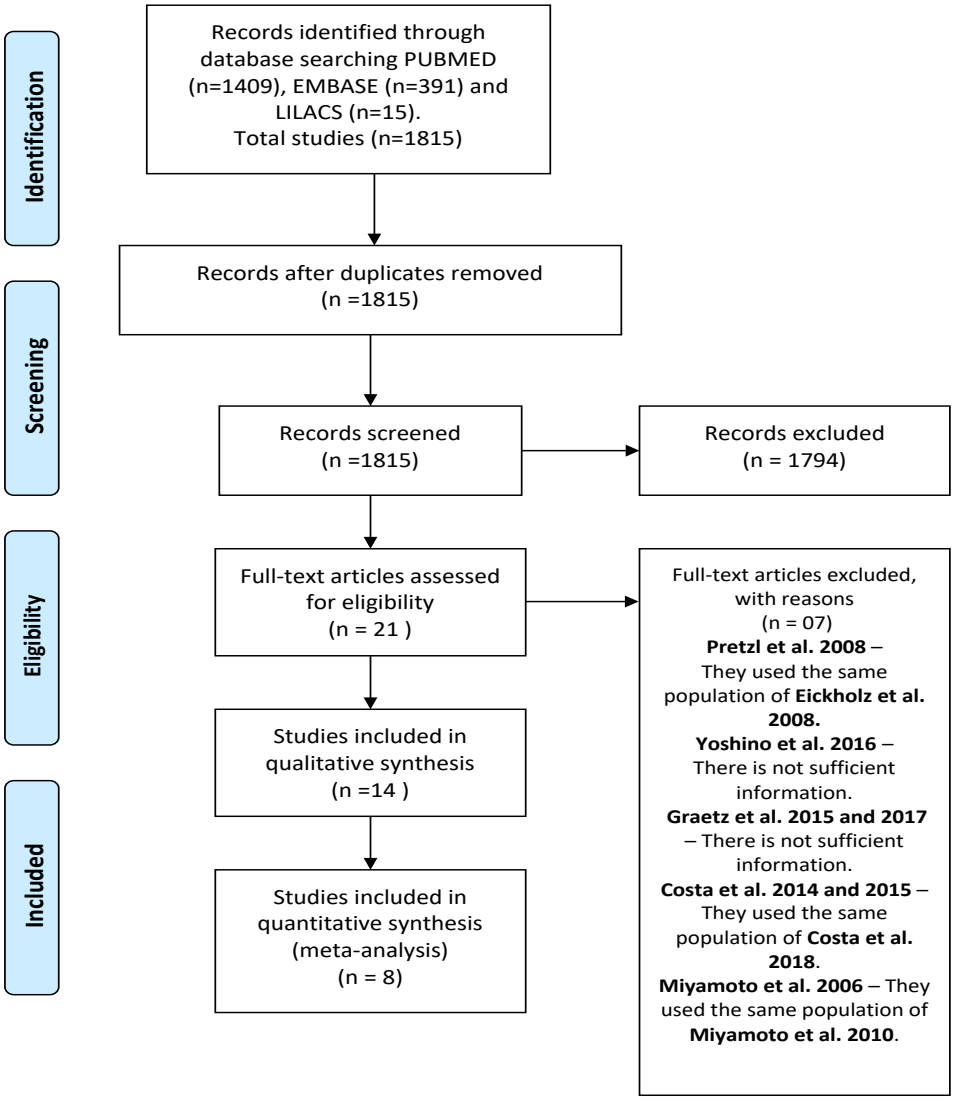

Figure 1. Flow diagram.

2010; Miyamoto *et al.*, 2010; Baumer *et al.*, 2011; Ng *et al.*, 2011; Kim *et al.*, 2014; Seirafi *et al.*, 2014; Díaz-Faes *et al.*, 2016; Petit *et al.*, 2019). Their characteristics are shown in Table 2. 2; 428 individuals of both sexes, ranging from 19 to 80 years were included. All studies evaluated the exposure (compliance and non-compliance to SPT) by records assessment. Regarding the outcome assessment, tooth loss was determined by clinical examination in all 13 studies.

Prospective study

Only one of the 14 included studies was prospective (Costa, *et al.*, 2018). The characteristics are shown in Table 3. The study followed 56 individuals of both sexes, aged 23 to 70 years, and subjects were followed for six years. Exposure (compliance to supportive periodontal therapy) and outcome (tooth loss) were assessed by clinical examinations.

Methodological quality of included studies

Retrospective studies

NOS domains were used to assess the quality of retrospective studies included in this review. Of the 13 included retrospective studies (Table 4), seven were considered to have low risk of bias (Eickholz *et al.*, 2008; Matuliene *et al.*, 2010; Miyamoto *et al.*, 2010; Baumer *et al.*, 2011; Ng *et al.*, 2011; Stadler *et al.*, 2017; Petit *et al.*, 2019), five moderate risk (Kocher *et al.*, 2000; Checchi L *et al.*, 2002; Tsami *et al.*, 2009; Kim *et al.*, 2014; Díaz-Faes *et al.*, 2016) and one was considered to present a high risk of bias (Seirafi *et al.*, 2014).

Prospective study

The risk of bias from the prospective study is shown in Table 5, and the included study was considered to have a low risk of bias (Costa *et al.*, 2018).

Table 2. Characteristics of the retrospective studies.

Author (Country)	Subjects characteristics	Periodontitis classification	Compliance to SPT assessment	Outcome assessment	Main findings	Conflict of interest
Bäumer *et al*. 2011 (Germany)	84 patients age 20-36 years; 68 woman and 16 man from University Hospital Heidelberg Number of patients at baseline: RC: 24 patients NC: 60 patients Retrospective Study	Aggressive Periodontitis	Evaluation of patients' charts RC: a frequency of at least two visits per year NC: if someone had extended the recall interval once over 100% (i.e. returning after 13 months for SPT)	Clinical examination Outcome: tooth loss during SPT Follow up: 10.5 years Recommended intervals of SPT: 2 visits per year	Tooth loss: RC: loss of 0.79 ±18 teeth per patient NC: loss of 1.57 ± 2.74 teeth per patient	The authors reported no conflicts of interest related to this study.
Checchi *et al*. 2002 (Italy)	92 adult subjects age 45 years (28–65); 75 woman and 37 man from a private periodontal office Number of patients at baseline: RC: 59 patients NC: 33 patients Total of 2310 teeth with an average of 25 teeth in each patient at the beginning of SPT. Retrospective study	Chronic Periodontitis	Evaluation of patients' charts RC: 3- or 4-month interval of SPT NC: intervals less than 3 months	Clinical examination Outcome: tooth loss during SPT Follow up: 6.7 years, with a (3–12 years) Recommended intervals of SPT: at least 3 visits per year	Tooth loss: Study demonstrated that NC patients were 5.6 times more likely to lose teeth during the maintenance phase than RC patients.	Authors did not provide conflict of interest information
Díaz-Faes *et al*. 2016 (Spain)	25 patients age 30.8± 4.1; 17 woman and 6 man from a periodontal private practice clinic in Málaga Number of patients at baseline: RC: 7 patients NC: 18 patients Total of 656 teeth at the beginning of SPT Retrospective Study	Aggressive Periodontitis	Evaluation of patients' charts RC: if they had attended all SPT appointments during the entire observation period every 4-6 months NC: if they had missed one appointment	Clinical examination Outcome: tooth loss Follow-up:10.9±2.0 years Recommended intervals of SPT: every 4-6 months	Tooth loss: RC: total lost of 8 teeth NC:: total lost of 14 teeth The mean tooth loss per patient was 0.9 ± 2.0 for periodontal disease.	The authors reported no conflicts of interest related to this study.

Table 2 continued overleaf

Table 2. Characteristics of the retrospective studies continued...

Eickholz *et al.* 2008 (Germany)	100 patients age 15–67 years (mean age 46.6 ± 10.3); 59 woman 41 man from the University Hospital Heidelberg Number of patients at baseline: RC: 53 patients NC: 47 patients A total of 2301 teeth at the beginning of SPT. Retrospective Study	Aggressive + Chronic Periodontitis	Evaluation of patients' charts RC: if they had attended all SPT appointments during SPT every 3-month intervals during the first year and later on in 6 months intervals. NC: if they had missed one appointment	Clinical examination Outcome: tooth loss during SPT Follow-up:10 years Recommended intervals of SPT: 3-month intervals during the first year of SPT and later on in 6-month intervals	Tooth loss: RC: loss of 0.55± 0.99 teeth per patient. NC: loss of 2.68 ± 4.44 teeth per patient.	The authors reported no conflicts of interest related to this study.
Kim *et al.* 2014 (Korea)	142 patients, mean age of the patients was 47.3 years (range, 21–72 years), from the Department of Periodontics, Gangneung-Wonju National University Dental Hospital Number of patients at baseline: RC: 15 patients NC: 102 patients. Number of teeth at baseline: RC: 344 teeth NC: 2515 teeth Retrospective Study	Chronic Periodontitis	Evaluation of patients' charts (1999 to 2001) RC: patients who continued to attend their appointments in 2011 and had attended more than 80% of their recommended SPT appointments. NC: patients who continued to attend their appointments in 2011 and had attended less than 80% of their recommended SPT appointments or patients who had returned at least once for SPT but did not continue.	Clinical examination Outcome: tooth loss during SPT Follow-up: 11 years (range, 9.7–13.4 years). Recommended intervals of SPT: every 3 to 6 months	Tooth loss: RC: loss of 23 teeth NC: loss of 48 teeth	The authors reported no conflicts of interest related to this study.
Kocher *et al.* 2000 (Germany)	67 patients, 29 woman and 38 man from Department of Periodontology at the University of Kiel. Untreated patients (A) age aged 45.9 ± 13.9 years. NC (B) 45.5 ± 5.8 years RC (C) 46.6 ± 7 years Number of patients at baseline: RC: 27 patients NC: 26 patients Untreated: 14 patients Total of 1525 teeth at baseline. Retrospective Study	Chronic Periodontitis	Evaluation of patients' charts Untreated patients: patients who discontinued supportive periodontal treatment and there after received no further periodontal care NC: patients completed the hygienic phase and periodontal surgery, and didn't come regularly RC: came to the scheduled maintenance appointments 2 to 4 times a year.	Clinical examination Outcome: desease progression of periodontitis Follow-up: 7 years Recommended intervals of SPT: 2 – 4 times per year	Tooth loss: RC: loss of 2.0 teeth per patient NC: loss of 3.8 teeth per patient	Authors did not provide conflict of interest information

Table 2 continued overleaf

Table 2. Characteristics of the retrospective studies continued...

Matuliene *et al*. 2010 (Switzerland)	160 patients, age 15–71 years of age (mean: 46.7± 10.9 years); 88 woman and 72 man from the University of Berne Number of patients at baseline: RC: 118 patients NC: 42 patients Number of teeth at baseline: RC: 2677 teeth NC: 894 teeth Retrospective Study	Chronic Periodontitis	Evaluation of patients' charts RC: visits every 3–6 months NC: patients who missed any of the suggested maintenance visits, but continued to appear irregularly	Clinical examination Outcome: molar and non-molar loss during SPT Follow-up: 9.5 ± 4.5 years. Recommended intervals of SPT: 2 – 4 times per year	Tooth loss: RC: lost 127 teeth (4.7%) NC: lost 131 teeth (14.7%)	The authors reported no conflicts of interest related to this study.
Miyamoto *et al*. 2010 (Japan)	295 subjects from a private practice Number of patients at baseline: RC: 98 patients NC: 197 patients Retrospective Study	Chronic Periodontitis	Evaluation of patients' charts Compliance I: RC: patients who attended at least 70% of the expected maintenance visits NC: who failed to attend >30% of the expected maintenance visits Compliance 2: RC: patients who attended most scheduled maintenance visits IC: patients who failed to attend a maintenance visit for a minimum of 2 years during the maintenance therapy.	Clinical examination Outcome: tooth loss during SPT ‡20 years of Recommended intervals of SPT: 2 – 4 times per year	Tooth loss: Compliance 1 RC : 222 teeth NC: 426 teeth Compliance 2 (after 2 year): RC: 216 teeth NC: 412 teeth	The authors reported no conflicts of interest related to this study.
Ng *et al*. 2011 (Singapore)	273 patients mean age 44.7 range 19-80; 167 woman and 106 man from the Departament of Restorative Dentistry, National Dental Centre Singapore Number of patients at baseline: RC: 239 patients IC: 34 patients Number of teeth at baseline: RC: 6199 teeth IC: 887 teeth Retrospective Study	Chronic Periodontitis	Evaluation of patients' charts RC: at least two thirds of interval 2 and 6 months visits NC: less than two thirds of interval 2 and 6 months visits	Clinical examination Outcome: tooth loss during SPT Follow-up: 7 years Recommended intervals of SPT: 2 – 6 times per year	Tooth loss RC: 0.09 tooth loss/ patient/year. Loss of 228 teeth. NC: 0.7 tooth loss/ patient/year. Loss of 25 teeth.	The authors reported no conflicts of interest related to this study.

Table 2 continued overleaf

Table 2. Characteristics of the retrospective studies continued...

Petit *et al*. 2019 (France)	101 pacients age 51 ± 10.3 years; 50 woman and 51 man from the University Hospitals of Strasbourg Number of patients at baseline: Compliance 1 RC: 53 patients NC: 48 patients Compliance 2 RC: 60 patients NC: 41patients Retrospective Study	Aggressive + Chronic Periodontitis	Evaluation of patients' charts RC: patiants who went in every schedule appointment 2 visits per year. NC: less than 1.4 visits per year, missing > 30% of these recommended visits	Clinical examination Outcome: tooth loss during SPT Follow-up: 9.72 +- 1.17 years Recommended intervals of SPT: 2 – 4 times per year (depending on the APT and SPT outcomes)	Tooth loss RC: 6,91% of patients experienced tooth loss NC: 6,42% of patients experienced tooth loss	The authors reported no conflicts of interest related to this study.
Seirafi *et al*. 2014 (Iran)	72 patients, 52 women and 20 men, age ranged from 30 to 78 years (mean age 51.30 ± 10.24 years) from a periodontal private practice Number of patients at baseline: RC: 21 patients NC: 51 patients Number of teeth at baseline: RC: 25.63 ± 3.46 teeth NC: 26.27 ± 2.14 teeth Retrospective Study	Chronic Periodontitis	Evaluation of patients' charts RC: attended at least 70% of the expected visits, attended at least 14 appointments NC: failed to attend more than 30% of expected visits and attended no more than 6 appointments during the recall period	Clinical examination Outcome: tooth loss during SPT Follow-up: 10 years Recommended intervals of SPT: 2 – 4 times per year	Tooth loss: RC: 24 teeth were lost (23.07%) NC: 80 teeth were lost (76.93%)	The authors reported no conflicts of interest related to this study.
Stadler *et al*. 2017 (Brasil)	737 patients, 432 women and 305 men, age 46.6±13.0 from a periodontal private practice in Porto Alegre Number of patietns at baseline: RC: 414 patients NC: 323 patients Retrospective Study	Aggressive + Chronic Periodontitis	Evaluation of patients' charts RC: 2 times a year NC: SPT less than 2 times a year	Clinical examination Outcome: tooth loss during SPT Follow-up: 7.4±6.0 years Recommended intervals of SPT: 2x a year	Tooth loss: Number of patients who experience tooth loss: RC: 91 patients had tooth loss NC: 111 patients had tooth loss	Authors did not provide conflict of interest information

Table 2 continued overleaf

Table 2. Characteristics of the retrospective studies continued...

Tsami *et al*. 2009 (Greece)	280 patients 154 woman, 126 men age ranged from 43 to 62 years with a mean age 51.64 ± 6.34 years from a private periodontal practice in Athens Number of patietns at baseline: RC: 148 patients NC: 132 patients Total: 6.673 teeth at baseline Retrospective Study	Chronic Periodontitis	Evaluation of patients' charts RC: kept at least 75 percent of the scheduled maintenance appointments NC: kept more than 40 percent but less than 75 percent of the scheduled maintenance appointments	Clinical examination Outcome: tooth loss during SPT Follow-up: 16 years with a mean 10.84 ± 2.13 years Recommended intervals of SPT: 3 – 4 times per year	Tooth loss: RC: 364 teeth NC: 554 teeth	Authors did not provide conflict of interest information

SD: standard deviation; RC: regular compliers; NC: Noncomplince; SPT: Supportive periodontal therapy.

Table 3. Characteristics of the prospective cohort study.

Author (Country)	Subjects characteristics	Periodontitis Definition	Compliance to SPT assessment	Outcome assessment	Main findings	Conflict of interest
Costa *et al*. 2018 (Brazil)	56 individuals, aged 23 through 70 years; 28 woman and 28 man from a private dental clinic in Belo Horizonte Number of teeth at baseline: RC: 23.9±2.9 teeth NC: 24.0±2.8 teeth Number of patients at baseline: RC: 28 patients NC: 28 patients Prospective cohort study	Chronic Periodontitis	Clinical examination RC : maximum visit interval period of 6 months NC individuals who missed any of the PMT visits but with a maximum between visit interval of 18 months	Clinical examination Oucome: tooth loss during SPT Follow up: 6 years Recommended intervals of SPT: at least 2 visits per years	Tooth loss: RC: 12 teeth (mean 0.7 ± 0.8 teeth lost) NC: 39 teeth (mean 1.8 ± 1.4 teeth lost)	The authors reported no conflicts of interest related to this study.

RC: regular compliers; NC: noncompliers; SPT: Supportive periodontal therapy.

Table 4. Methodological quality of the retrospective studies.

	Selection (maximum 5)	Comparability (maximum 2)	Outcome (maximum 2)	Statistics (maximum 1)	Total (maximum 10)
Baumer *et al*. 2011	3★	2★	1★	1★	7★
Checchi *et al*. 2002	4★	0★	1★	1★	6★
Diaz-Faes *et al*. 2016	2★	2★	1★	1★	6★
Eickholz *et al*. 2008	5★	2★	1★	1★	9★
Kim *et al*. 2014	3★	0★	1★	1★	5★
Kocher *et al*. 2000	3★	1★	1★	1★	6★
Matuliene *et al*. 2010	4★	2★	1★	1★	8★
Miyamoto *et al*. 2010	3★	2★	1★	1★	7★
Ng *et al*. 2011	3★	2★	2★	1★	8★
Petit *et al*. 2019	3★	2★	1★	1★	7★
Seirafi *et al*. 2014	2★	0★	1★	1★	4★
Stadler *et al*. 2017	3★	2★	1★	1★	7★
Tsami *et al*. 2009	2★	2★	1★	1★	6★

Scores ranged from 0 to 10 stars. Studies with 7-10 stars were arbitrarily rated as low risk of bias, 5-6 stars moderate risk of bias and < 5 high risk of bias.

Table 5. Methodological quality of the prospective study.

	Selection (maximum 5)	Comparability (maximum 2)	Outcome (maximum 3)	Statistics (maximum 1)	Total (maximum 11)
Costa *et al*., 2018	4★	2★	3★	1★	10★

Scores ranged from 0 to 11 stars. Studies with 7-11 stars were arbitrarily rated as low risk of bias, 5-6 stars moderate risk of bias and < 5 high risk of bias.

Pooled outcomes

Retrospective studies

Overall meta-analysis demonstrated that noncompliant patients to SPT have 26% increased risk of tooth loss when compared with compliant individuals (OR = 1.26; 95% CI = 1.06 to 1.51, Heterogeneity: $I^2 = 0\%$, $p = 0.008$), (Figure 2). In addition, a subset analysis comparing different recommendations regarding periodontal maintenance intervals revealed a significant effect only for 3 to 6 months recalls (OR = 1.27; 95% CI = 1.02 to 1.57, Heterogeneity: $I^2 = 0\%$, p = 0.03).

Prospective study

Descriptive analysis of the study showed that during the 6-year monitoring period the compliant SPT group lost 12 teeth (mean 0.7 ± 0.8 teeth lost) and non-compliant SPT group lost 39 teeth (mean 1.8 ± 1.4 teeth lost), reflecting a higher tooth loss rate among non-compliant subjects.

Discussion

The main results of the present systematic review indicate that in patients with periodontitis, the non-compliers to SPT have an increased risk of tooth loss when compared with compliant individuals. Overall meta-analysis of data from retrospective studies shows that non-compliers to SPT have a 26% increased risk of tooth loss when compared to compliers. These findings are in agreement with a previous review (Lee *et al*., 2015) which showed that compliant individuals to SPT have less risk of teeth loss. However, besides the difference that the above-mentioned review focused the analysis on compliers, and the present review on the non-compliers to SPT, other points should be pointed out; 1) Lee *et al*., 2015 conducted the literature search more than five years ago, and since then, the base of evidence has improved (Díaz-Faes *et al*., 2016; Stadler *et al*., 2017; Costa *et al*., 2018); 2) The meta-analysis conducted in the previous review inadequately combined prospective and retrospective studies, and 3) the new classification

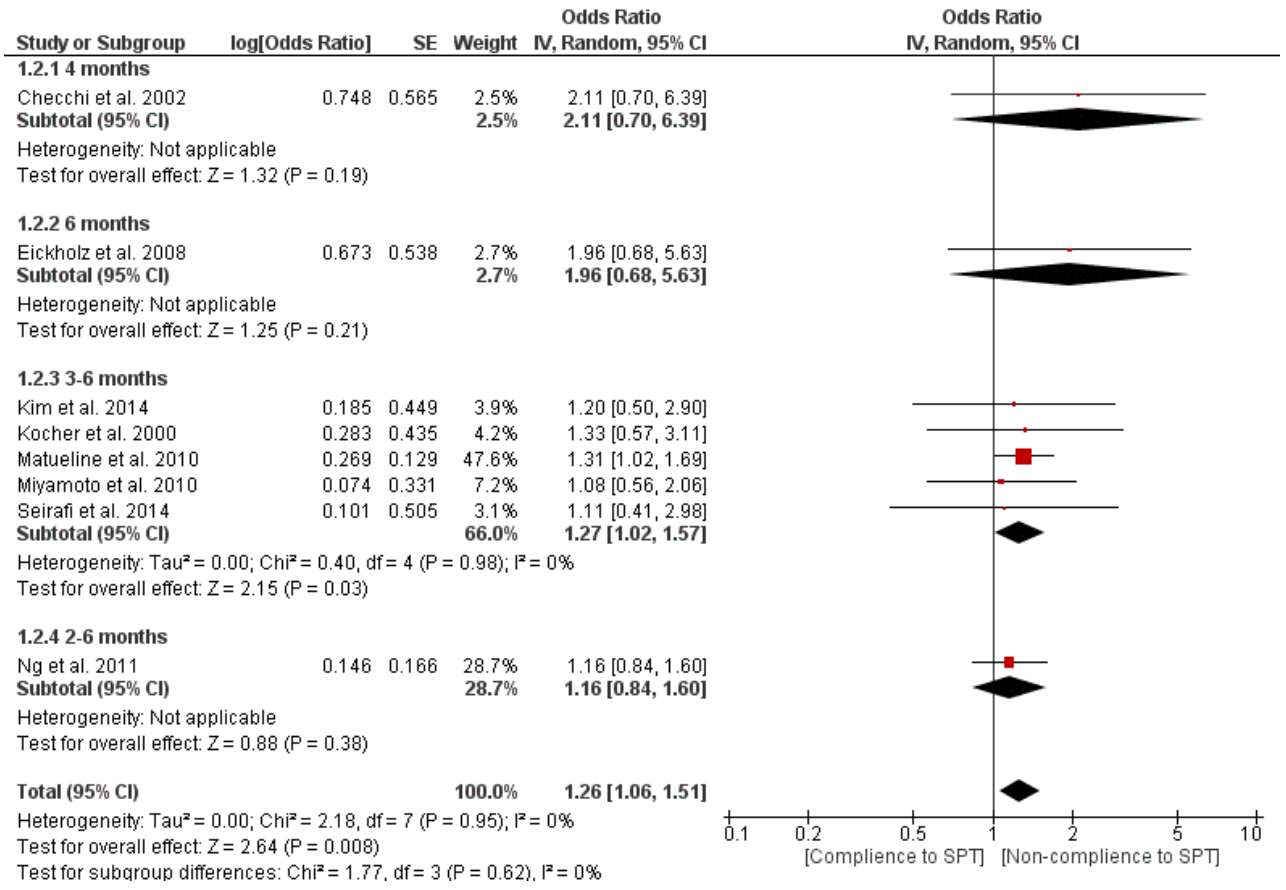

Figure 2. Forest plot for meta-analysis of tooth loss in compliers to SPT compared to non-compliers in retrospective studies (n = 08 studies).

of periodontal diseases (Papapanou *et al.*, 2018) no longer subdivides chronic and aggressive periodontitis, and the present study included both conditions in the literature search.

When patients do not regularly attend for SPT, their oral hygiene monitoring and motivation is not performed, resulting in an increase in plaque index, increased bleeding on probing, increased probing depth (Axelsson and Lindhe, 1981; Axelsson *et al.*, 2004), and re-establishment of subgingival periodontal pathogenic microbiota (Costa *et al.*, 2018). In addition, patients who do not have their periodontal risk recalculated lose the opportunity to re-treat sites in cases that the periodontal disease recurs (Lang *et al.*, 2015). Together, all of these facts may explain the increased tooth loss rate in patients not compliant to SPT.

Some methodological differences with regards to SPT intervals among studies should be considered. While one study recommended that patients considered compliers should attend to SPT every four months. (Checchi *et al.*, 2002), other studies recommended six months (Eickholz *et al.*, 2008), three to six months (Kocher *et al.*, 2000; Matuliene *et al.*, 2010; Miyamoto *et al.*, 2010; Kim *et al.*, 2014; Seirafi *et al.*, 2014) and two to six months (Ng *et al.*, 2011). In this way, subset analysis of the present SR demonstrated that, so far, the most significant evidence is for 3-6 months maintenance intervals according to risk factors and non-complier individuals for this program have a 27% increased risk of tooth loss. Although the above-mentioned data was obtained from retrospective studies, there are no clinical trials comparing different periodontal maintenance intervals on tooth loss. Indeed, a recent systematic review of clinical trials concluded that there is no evidence available to determine the merits of SPT provided at different time intervals (Manresa *et al.*, 2018).

The newest classification of periodontal diseases includes staging and grading of periodontitis (Papapanou *et al.*, 2018). While staging is linked to periodontitis severity, extent and treatment complexity, grade captures the risk of disease progression (Caton *et al.*, 2018). Even though it seems reasonable that grade A (low risk), grade B (moderate risk) and grade C (high risk) may require different SPT intervals to obtain periodontitis progression control, there is no evidence yet to support this statement. Therefore, further studies assessing the effects of SPT at different intervals on individuals with different periodontitis grades are needed, all these in order to determine the best periodontal maintenance interval according to the proposed diagnosis.

Further, the present SR highlights the lack of studies on the effect of being compliant to SPT in rapid progression periodontitis (Aggressive periodontitis). In fact, only two retrospective studies assessed patients with aggressive periodontitis (Bäumer *et al*., 2011; Díaz-Faes *et al*., 2016) and three other studies combined patients with chronic and aggressive periodontitis (Eickholz *et al*., 2008; Stadler *et al*., 2017; Petit *et al*., 2019). Of these, only one study provided sufficient data and could be included in the meta-analysis (Eickholz *et al*., 2008).

All studies included in the present review had their methodical quality assessed by the NOS. Some important criteria were evaluated such as representativeness of the sample, ascertainment of exposure, management of confounding factors, outcome assessment and valid statistical analysis, and failure to meet any of these criteria may have influenced the results. Six retrospective studies (Bäumer *et al*., 2011; Eickholz *et al*., 2008; Matuliene *et al*., 2010; Miyamoto *et al*., 2010; Ng *et al*., 2011; Petit *et al*., 2019) and one prospective study (Costa *et al*., 2018) were rated to have low risk of bias, while other five retrospective studies (Kocher *et al*., 2000; Checchi *et al*., 2002; Tsami *et al*., 2009; Díaz-Faes *et al*., 2016; Kim *et al*., 2014) were considered to have moderate risk, and one high risk of bias (Seirafi *et al*., 2014). Moreover, it can be pointed out that that most studies do not describe the cause of tooth loss. This information could have helped to provide a better understanding of the relationship between compliance to SPT and tooth loss due to periodontitis. Also, since data were obtained mostly from retrospective studies, which are associated with greater heterogeneity and bias, results from the present SR should be interpreted with caution.

Conclusion

Despite the limitations of the included studies, the present SR concludes that patients with periodontitis not compliant to SPT have an overall 26% higher risk of tooth loss when compared to compliers. Therefore, oral health professionals should implement measures to obtain as much adherence as possible to SPT.

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