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Retention of periodontally hopeless tooth and the clinical effect on the adjacent tooth at maintenance phase: A retrospective study

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Abstract

Previous research has shown that periodontal maintenance therapy can keep teeth healthy for a long time. However, only a few studies have been conducted on the periodontal hopeless tooth that is retained during the maintenance phase. The purpose of this study was to evaluate if retaining a periodontal hopeless tooth had an effect on the periodontal conditions in the adjacent tooth at maintenance. A retrospective analysis was conducted on the periodontal status of periodontitis patients who presented with retained hopeless tooth. Hopeless prognosis is based on the mean percentage of the mesial and distal radiographic bone loss ≧ 65%. The periodontal status consists of periodontal pocket depth (PPD), clinical attachment loss (CAL), and bleeding on probing (BoP), which were evaluated at baseline (T0), after active therapy (T1) and at the last examination (T2) for both the hopeless tooth and the tooth/teeth adjacent to it. Compliance toward maintenance and reason for hopeless tooth extraction were also evaluated at maintenance (T1-T2). A total of 65 patients with 121 hopeless teeth and 187 adjacent teeth were included. Significant improvement of all periodontal parameters for both hopeless and adjacent teeth at T1 and T2 from T0 were observed within 5.05±2.58 years of observation, except for the CAL during maintenance. In conclusion, a low risk of disease progression on the tooth adjacent to the retained periodontal hopeless tooth can be achieved following active treatment with strict maintenance care.

Keywords: *hopeless tooth, periodontitis, periodontal maintenance, retention, tooth loss*

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Introduction

The main goal of periodontal therapy is to preserve natural teeth by arresting the progression of attachment loss (Nicholls, 2000). Several studies have reported the effectiveness of periodontal treatment in preventing tooth loss (Cortellini & Tonetti, 2004; Graetz *et al.*, 2011; Graetz *et al.*, 2017). Following a good maintenance care programme, the prolonged survival of periodontally compromised teeth can be Achieved (Hirschfeld & Wasserman, 1978; Matuliene *et al.*, 2008). However, in some situations, the extraction of periodontally compromised tooth is recommended. The extraction usually involves teeth that are indicated as 'hopeless', mainly due to advanced periodontal destruction. The majority of these teeth were extracted during active therapy (APT), while some of the remaining are likely to be extracted

during the supportive phase (Carnevale *et al.*, 2007; Matuliene *et al.*, 2008).

The decision of assigning the tooth as a hopeless is mainly based on local-tooth related and systemic factors (Checchi *et al.*, 2002; Machtei &Hirsch, 2007; Mcguire &Nunn, 1996; Nguyen *et al.*, 2020; Wojcik *et al.*, 1992). Although the majority of teeth lost due to periodontal disease had been initially assigned as questionable or hopeless prognosis, cases of improvement of state have been encountered (Graetz *et al.*, 2011). This indicates that it is not always possible to definitively identify teeth at risk of being lost with prognosis alone. Therefore, extractions conducted during APT should be performed with caution.

In clinical practice, the decision to treat or extract a tooth is often based on the assumption that the retention of a hopeless tooth may accelerate periodontal tissue destruction of the adjacent tooth. Therefore, as a preventive measure, "strategic extractions" have been advocated (Kao, 2008; Lin *et al.*, 2019; Lundgren *et al.*, 2008). As patients may refuse to have their periodontally hopeless tooth extracted due to milder symptoms, it is important to base the intervention on whether the patient will benefit from the extraction.

The impact of retaining hopeless teeth on the adjacent periodontium has been studied previously, and was found that it had no negative effect on the proximal alveolar bone and PPD of the adjacent teeth following periodontal therapy (Devore *et al.*, 1988; Machtei &Hirsch, 2007; Wojcik *et al.*, 1992). However, no evaluation was made on other periodontal parameters, such as clinical attachment loss (CAL) and bleeding on probing (BoP). Nonetheless, the outcomes on PPD, CAL and BoP are clinical signs widely used as indicators of periodontal disease progression (Lang *et al.*, 2009; Matuliene *et al.*, 2008; Mdala *et al.*, 2014). Therefore, it is relevant to observe the impact of the retention of the hopeless tooth on the clinical parameters of the adjacent tooth.

Materials and Methods

Data Collection

This retrospective study consisted of patients with periodontal disease who were treated at the Mak Mandin Periodontal Specialist Clinic in Penang. To identify patients with periodontal hopeless teeth, a comprehensive review of all clinical records and radiographs from 2010 to 2019 was performed. The patients were then screened to include only those with hopeless teeth remained in the maintenance phase. All other clinical information was also extracted from the case note and radiography records.

For the purpose of this study, prognosis for a hopeless tooth was solely based on radiographic assessment at baseline. The percentage of alveolar bone loss was measured based on the formula [distance from cemento-enamel junction (CEJ) to the most apical extension of the alveolar bone crest (BL) / root length from the apex (AP) to the CEJ] X 100. If a restoration was presented over the CEJ, the margin of the restoration was used as the reference point. Measurement was done on each proximal (mesial and distal) surfaces. The mean percentage of alveolar bone loss (% mesial + % distal / 2) at ≧ 65% was considered as hopeless (Figure 1). Measurements were performed by a single examiner (M.A.J). Manual measurements for conventional radiographs, such as periapical and panoramic were performed under standardized viewing conditions using a negatoscope, and a transparent plastic ruler to the nearest millimetre. For the digital radiographs, measurements were done using a computerized software.

Intra-examiner reliability was calculated based on a repeated radiographic assessment of 30 teeth (a combination of 15 conventional and 15 digital radiographs) at 1-week intervals, using Intraclass Correlation Coefficient (ICC). The average ICC was 0.998 with a 95% confidence interval from 0.995 to 0.999 (P<0.001). These outcomes demonstrated that the performed measurements were standardized.

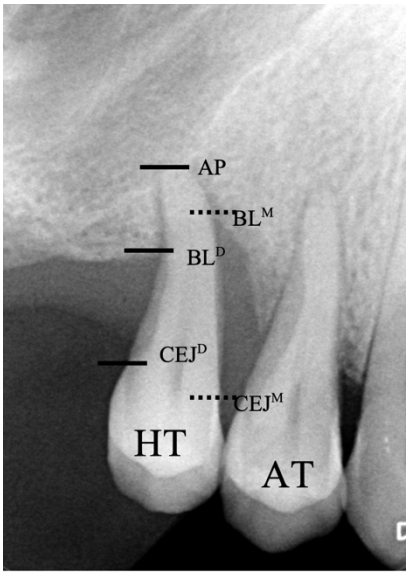

Figure 1. References for alveolar bone loss measurement. Hopeless tooth determination, based on mean percentage between mesial and distal bone loss (≥ 65%). Inclusion was based on the presence of adjacent tooth/teeth with less than 65% bone loss, and survival of hopeless tooth at maintenance (T1-T2) for a minimum of one year.

$$\frac{CEJ^{M} - BL^{M}}{CEJ^{M} - AP} \times 100 = M\%$$

$$\frac{CEJ^{D} - BL^{D}}{CEJ^{D} - AP} \times 100 = D\%$$

Mean percentage of alveolar bone loss:

$$\frac{\mathbf{M + D}}{\mathbf{2}} = \mathbf{BL\%}$$

Hopeless tooth when the BL% ≥ 65%.

Inclusion and exclusion criteria

Patients were included in the study when three sets of periodontal examinations are available: at baseline (T0), after APT (T1) and at last examination (T2). Hopeless tooth needs to survive after the APT, with at least one adjacent tooth (mean BL <65%) and both retained for a minimum of one year from T1. Patients were excluded if they received regenerative therapy of either the hopeless and adjacent teeth.

Periodontal evaluation

At baseline (T0), three clinical parameters; PPD, CAL, and BoP measurements were extracted from the clinical note for both hopeless and adjacent teeth. Similar clinical parameters were evaluated at T1 and T2.

Tooth loss and reasons for it at time points T1 to T2 were also assessed. Any unidentified reason for missing of initially prognosed as 'hopeless' will be assumed as 'extracted due to periodontal reason'.

Periodontal therapy

All patients received initial non-surgical periodontal therapy (scaling and root debridement, under local anaesthesia if necessary), together with oral hygiene instructions. Systemic antibiotics were prescribed as an adjunct to scaling and debridement for generalized aggressive periodontitis, according to Griffiths *et al.* (2011). Periodontal surgery (resective, or open flap debridement) was performed if indicated. Those who received periodontal regenerative therapy were excluded from the study.

Maintenance visits

Maintenance visits per year were determined for each patient by dividing the number of visits by the number of years between T1 to T2 (Checchi *et al.*, 2002). The level of compliance towards maintenance was defined as good or poor. Level of compliance was considered as 'good' if patients reliably and consistently presented for the maintenance and completely complied with the proposed intervals during the entire duration of T1 to T2. Patients who did not consistently follow the prescribed maintenance visits, but still continued to irregularly appear were identified as 'poor' compliers. Patients who were missed or did not comply with the suggested maintenance visits (non-compliers) were not included in the study. Non-compliers were excluded due to breaching of the inclusion criteria. Majority of these patients were not available for a re-evaluation at T2 of more than 1 year.

Statistical analysis

Statistical analyses were performed using the IBM SPSS for Windows, version 26 (IBM Corp., Armonk, N.Y., USA). Changes for mean PPD, CAL, and percentage of BoP from T0 to T1 and from T0 to T2 were independently calculated using the Wilcoxon signed-rank test. The same test was used for changes between levels of compliance toward periodontal maintenance at T1 to T2. Logistic regression was used to determine periodontitis progression variables. Several independent factors were looked at, such as the smoking, and diabetes. Statistical significance was declared for *p*-values of <0.05.

This study was approved by the Medical Research and Ethics Committee (MREC), Ministry of Health Malaysia (NMRR-21-581-59184 IIR). The ethics committee waived the need to obtained consent for the data collection, analysis and publication of the retrospectively obtained secondary data for this non-interventional study.

Results

Demographic data

The 65 patients diagnosed with periodontitis were evaluated between 2010 and 2019. Table 1 presents the characteristics of the sample, including gender, mean age at first visit, general health, mean frequency of maintenance, mean follow-up length, number of hopeless and adjacent teeth, and percentage of bone loss. It is important to note that most of the patient (93.80%) were none smoker. In addition to the findings presented in Table 1, nearly all patients (97%) were assessed for alveolar bone loss using conventional radiographs. Further data are shown in Table 1, 2, and 3.

Changes in clinical parameters of retained hopeless tooth and the adjacent tooth.

The clinical changes (PPD, CAL and BoP) of retained hopeless tooth and the adjacent tooth are demonstrated in Table 4. The mean PPD for hopeless tooth at baseline (T0) was significantly reduced ($P < 0.0001$) from 5.32 mm, SD $\pm$ 1.49 to 4.03 mm, SD $\pm$ 1.55 after APT (T1). A further significant improvement ($P < 0.0001$) was observed following maintenance therapy, with a mean PPD of 3.85 mm, SD $\pm$ 1.55 at the latest assessment (T2). Similar results were also observed for the adjacent tooth with significant PPD reduction ($P < 0.0001$) from T0 (4.52 mm, SD $\pm$ 1.44) to T1 (3.43 mm, SD $\pm$ 1.34), and to T2 (3.11 mm, SD $\pm$ 1.12).

Changes in mean CAL of the hopeless tooth were evidenced from T0 (7.50 mm, SD $\pm$4.19) to T1 (6.50 mm, SD $\pm$ 1.97) with a statistically significant reduction ($P < 0.0001$). However, CAL was increased at T2 (7.13 mm, SD $\pm$ 2.38), with no statistical significance difference from the T0 ($P = 0.439$). Similarly, a slight increase in CAL at T2 (5.01 mm, SD $\pm$ 2.06) from the T1 (4.95 mm, SD $\pm$ 1.82) was observed for the adjacent tooth as well. Nevertheless, the CAL value was below baseline (T0) (5.60 mm, SD $\pm$ 1.80), and the reductions were statistically significant ($P < 0.0001$) at T0-T1, and T0-T2.

Table 1. Demographic data, maintenance period, follow-up period.

Patient	**n = 65**	
Age (mean ± SD)	45.15 ± 9.12	
Gender		
Male	25	(38.50%)
Female	40	(61.50%)
Medical status		
Healthy	41	(63.00%)
Diabetes	8	(12.40%)
Hypertension	16	(24.60%)
Smoking		
No	61	(93.80%)
Yes	4	(6.20%)
Radiograph		
Panoramic/conventional	59	(90.80%)
Periapical/conventional	4	(6.20%)
Periapical/digital	2	(3.00%)
Maintenance		
Mean ± SD frequency per year	2.94 ± 1.16	
Follow-up period (mean ± SD)		
T0-T1 (month)	1- 21 m	(4.03 ± 3.87)
T0-T2 (year)	2 - 10 y	(5.05 ± 2.58)
T1-T2 (year)	2 - 10 y	(4.48 ± 2.63)

Table 2. Number of teeth, percentage of alveolar bone loss, and type of teeth that retained after active periodontal therapy (T1).

Tooth:	
Hopeless	121
Adjacent	187
Total	308
% BL at T0 (mean ± SD):	
Hopeless	76.13% ± 8.28
Adjacent	45.33% ± 12.50

Table 3. Hopeless tooth that loss during the maintenance (T1-T2).

Loss:	**29**	**(23.97%)**
Reason for TL		
Pain	5	(17.25%)
Mobility	16	(55.17%)
Prosthetic reasons	6	(20.69%)
Caries or endodontic reasons	2	(6.89%)
Type of tooth extracted		
Maxillary molar	3	(10.34%)
Maxillary premolar	6	(20.69%)
Maxillary anterior	7	(24.14%)
Mandibular molar	5	(17.24%)
Mandibular premolar	4	(13.79%)
Mandibular anterior	4	(13.79%)

The mean percentage of BoP for the hopeless tooth at T0 was 66.30%, SD ± 31.64, which reduced to 37.74%, SD ± 34.14 at T1. The mean percentage continued to improve significantly to 33.33%, SD ± 28.30 at T2. A statistically significant (P < 0.0001) reduction in BoP percentage of the adjacent tooth were noted from T0 (50.83%, SD ± 35.06) to T1 (28.48%, SD ± 32.31), and to T2 (20.96%, SD ± 27.14).

Table 4. Means (+SD) of clinical parameters at baseline (T0), after active periodontal therapy (T1) and last examination (T2) for hopeless and adjacent teeth.

Clinical measurements	**Baseline (T0)**	**After APT (T1)**	**Last examination (T2)**	***P* value**	
				T0-T1	**T0-T2**
Hopeless tooth					
PPD (mm)	5.32 ± 1.49	4.03 ± 1.55	3.85 ± 1.55	< 0.0001	< 0.0001
CAL (mm)	7.50 ± 4.19	6.50 ± 1.97	7.13 ± 2.38	< 0.0001	0.439
BoP (%)	66.30 ± 31.64	37.74 ± 34.14	33.33 ± 28.30	< 0.0001	< 0.0001
Adjacent tooth					
PPD (mm)	4.52 ± 1.44	3.43 ± 1.34	3.11 ± 1.12	< 0.0001	< 0.0001
CAL (mm)	5.60 ± 1.80	4.95 ± 1.82	5.01 ± 2.06	< 0.0001	< 0.0001
BoP (%)	50.83 ± 35.06	28.48 ± 32.31	20.96 ± 27.14	< 0.0001	< 0.0001

PPD, periodontal pocket depth; CAL, clinical attachment loss; BoP, bleeding on probing.

Influence of maintenance status on the periodontal stability

Maintenance status was evaluated as T1-T2. The mean frequency of maintenance visits per year was (2.94 years, SD ± 1.16) (Table 1). Forty-two patients (64.62%) were deemed as good compliers, whereas 23 patients (35.38%) were deemed as poor-compliers. Patients who were good and poor compliers retained 77 and 44 hopeless teeth, respectively. Additionally, 119 adjacent teeth were evaluated from the good compliers and 68 AT from the poor compliers (Table 5).

Table 5. Means (+SD) of clinical parameters at (T1-T2) for hopeless and adjacent teeth according to the level of compliance to maintenance.

	Compliance level	T1	T2	*P* value
Hopeless tooth	**Good (n=77)**			
	PPD	4.10 ± 1.56	3.80 ± 1.59	0.180
	CAL	6.27 ± 2.01	6.94 ± 2.61	0.003
	BoP*	40.26 ± 35.08	30.95 ± 30.31	0.032
	Poor (n=44)			
	PPD	3.91 ± 1.55	3.93 ± 1.49	0.745
	CAL	6.91 ± 1.86	7.45 ± 1.90	0.023
	BoP*	33.33 ± 32.35	37.50 ± 24.15	0.501
Adjacent tooth	**Good (n=119)**			
	PPD	3.43 ± 1.35	3.08 ± 1.21	0.012
	CAL	4.69 ± 1.77	4.77 ± 2.07	0.484
	BoP	29.77 ± 31.01	18.49 ± 25.28	<0.0001
	Poor (n=68)			
	PPD	3.44 ± 1.34	3.17 ± 0.95	0.419
	CAL	5.39 ± 1.83	5.42 ± 1.98	0.896
	BoP	26.23 ± 34.59	25.28 ± 29.82	0.963

PPD, periodontal pocket depth; CAL, clinical attachment loss; BoP, bleeding on probing. The inter-group comparisons (good vs poor compliance) for the mean differences between T1-T2 showed no statistical differences except for *BoP of hopeless tooth (p =0.013); Wilcoxon test.

Changes in the clinical parameters were independently evaluated for hopeless and adjacent teeth at T1 to T2 according to patients' compliance status (Table 5). Hopeless tooth for patients with good compliance toward maintenance showed a reduction in PPD and BoP. From this data, statistically significant differences were only seen for BoP (*P*=0.032). CAL however, showed further statistically significant deterioration (*P*=0.003). For the poorly compliance patients, their hopeless tooth showed a further increase for all measured parameters, whereby only CAL showed a statistically significant difference (*P*=0.023). Meanwhile, for the adjacent tooth, improvements in the clinical parameters except for the CAL were observed for both good and poor compliers. However, only the good compliers group showed statistically significant improvement. A comparison was made between poor and good compliers, with only significant result observed for the BoP of the hopeless tooth (p =0.013). Others, failed to show any significant results.

Regression model

A univariate binary logistic regression was performed to predict the progression of periodontitis for adjacent and hopeless teeth from T1 to T2 based on smoking, and diabetes status. A case of periodontitis was considered to be progressive if there was ≥ 2mm CAL between two observation points (T1 and T2) during the maintenance phase. Both of these factors however, were not significantly related to the progression of periodontitis within this study (Table 6).

Table 6. Univariate binary logistic regression for the progression of periodontitis from T1 to T2.

	Factor	OR	95% CI	*P* value
Hopeless tooth	*Smoking*			
	No	1		
	Yes	0.216	(0.012 - 3.773)	0.216
	Diabetes Mellitus			
	No	1		
	Yes	0.985	(0.241 - 4.032)	0.983
Adjacent tooth	*Smoking*			
	No	1		
	Yes	1.089	(0.127 - 9.341)	0.938
	Diabetes Mellitus			
	No	1		
	Yes	0.966	(0.351 - 2.660)	0.946

Hopeless tooth loss and reasons for extraction

Hopeless tooth loss was analysed between the T1 and T2 period. From a total of 121 hopeless tooth present after APT (T1), 29 (23.97%) were lost at the maintenance phase; 16 (55.17%) due to mobility, followed by prosthetic reasons at 6 (20.69%), pain at 5 (17.25%), and caries/endodontic reasons at 2 (6.89%). The majority were the maxillary anterior teeth (24.14%) and the least were the maxillary molar teeth (10.34%) (Table 3).

Discussion

The decision to treat teeth diagnosed as periodontally "hopeless" is controversial. While most practices favors extraction, some patients may not have consented to the procedure. In such situations, the tooth is usually retained throughout the periodontal maintenance phase. The decision to retain should be accompanied by considerations on its benefit, and the possibilities of progression into deterioration and affects toward the adjacent tooth.

A previous study by Machtei & Hirsch (2007), found that providing surgical treatment on periodontally hopeless tooth can preserve the teeth for a mean of 4 years with significant bone gain. This was also observed on the adjacent tooth. The study also found no statistically significant difference to the bone level of the adjacent tooth with either retained or extracted hopeless tooth. Similarly, in another study, following periodontal therapy on retained periodontal hopeless tooth, no significant detrimental effects were observed on the periodontal pocket, alveolar bone loss, and periodontal ligament space width on the proximal periodontium of the adjacent tooth (Wojcik *et al.*, 1992). However, both studies had different definitions for hopeless prognosis. Wojcik defined hopeless tooth using a combination of multiple risk indicators, namely 78% alveolar bone loss,

residual PPD of 8 mm, Class III furcation, Class III mobility, poor crown-root ratio, root proximity and repeated periodontal abscess. A minimum of two criteria was required for a tooth to be deemed hopeless. While Machtei defined the hopeless prognosis simply based on radiographic residual alveolar bone loss of ≥ 70% at either of the tooth's proximal sites.

For current study, we used a definition by Machtei with minor modification. The mean percentage of alveolar bone loss was calculated, and tooth was defined as hopeless when alveolar bone loss was ≥ 65% (Figure 1). Because of severe bone destruction of the hopeless tooth, a surgical treatment was not possible due to extreme mobility. At the maintenance phase, all patients received standard periodic supragingival scaling. Subgingival debridement was also provided for an area with the pocket of > 4mm. It was observed that retention of the hopeless tooth did not result in deterioration of the periodontal status; in fact, there was a significant improvement in PPD, CAL, and BoP. The same was also observed for the adjacent tooth (Table 4), indicate that hopeless tooth and the tooth adjacent to them can be maintained without significant deteriorating effect on the periodontal health provided with good periodontal treatment and strict maintenance care.

In general, hopeless tooth for patient with poor compliance toward maintenance showed progression in periodontal destruction for all three parameters. However only CAL showed statistically significant result. Patient with good compliance on the other hand, showed further improvements for the periodontal parameters, except for CAL which deteriorate significantly from T1 to T2. For the adjacent tooth, stability of the periodontal parameters (except for CAL) can be observed for patients with either good or poor compliance toward the maintenance care. However, only patient with good compliance showed significant improvement for PPD and BoP. There was only BoP's parameter for the hopeless tooth that showed significant different statistically when compared between patients with good and poor compliance within this study. The findings of this study are supported by Costa *et al.* (2018). Their prospective study indicated that patients with regular periodontal maintenance had better plaque index, PPD, and BoP after 6 years compared to the irregular complier. An increase in the percentage of patients with CAL> 5mm could be seen at different study time points in those with irregular compliance.

Lack of significant difference between poor and good compliance levels from the studies may be influenced by intervals of the maintenance procedures. Matuliene *et al.* (2008) observed a three-fold increase in periodontitis progression for maintenance done less than twice a year (6 monthly), in comparison to patients with rigid and frequent maintenance. In the current study, the mean number of maintenance visits per year was 2.94 + 1.16. Therefore, even patient with poor maintenance category was monitored at every 4 months. This frequency is in line with the multi-factorial Periodontal Risk Assessment model proposed for high risk patients (Lang &Tonetti, 2003). This may explain why there were no significant differences between poor and good compliance for both hopeless and adjacent teeth except for BoP of hopeless tooth ($p = 0.013$) observed within this study (Table 5).

On the other hand, the result for CAL, showed a deteriorating trend in all categories, yet significant only seen in the hopeless tooth (Table 5). Nevertheless, progression of periodontitis was to be expected during maintenance. Matuliene *et al.* (2008) found that a significant increase in the number of periodontal pockets of PPD ≥ 5mm per patient (4.1 ± 5.3 to 5.4 ± 6.8) occurred during a mean maintenance of 11 years.

There were several definitions used to define recurrent or progression of periodontitis during long-term maintenance. The 5th European Workshop on Periodontology defines periodontitis recurrence as at least two teeth with a CAL≥ 3 mm between two observation periods

(Tonetti *et al.*, 2005). In contrast, Lorentz *et al.* (2009) defined it as a change in CAL at a single site more than 3 mm. While, the 2017 classification of periodontitis defines a rapid progression rate of periodontitis (Grade C) as CAL≥ 2mm over a 5-year period (Papapanou *et al.*, 2018). Despite differences, CAL is a key clinical determinant in predicting disease progression. This study therefore considered teeth with the periodontitis recurrent if the CAL ≥ 2mm between T1 and T2.

The progression of periodontitis might eventually result in the loss of teeth. From a total of 121 hopeless tooth at T1, 29 teeth (23.97%) were lost during maintenance (T1-T2). The main reasons for extraction were mobility, followed by prosthetic reasons, pain, and caries/endodontic factors. Anterior teeth were generally lost more frequently than molars (37.93% vs 27.58%). On the contrary, previous studies found that multi-rooted teeth were most frequently lost during maintenance (Checchi *et al.*, 2002;Hirschfeld &Wasserman, 1978). This may be related to the low number of retained hopeless molar teeth (34.71%) presented after T1, compared to a higher retention of the anterior teeth (44.63%). The lack of extraction of the anterior teeth may be also due to aesthetic reasons. Since there is no particular research on patient perception elements related to the decision of anterior teeth extraction in periodontitis, one can only speculate based on study of oral health-related quality of life (OHRQoL) on anterior tooth loss. Several studies demonstrate that anterior tooth loss has a greater impact on patients in terms of both function and aesthetics (Al-Omiri *et al.*, 2009;Tsakos *et al.*, 2004;Tsakos *et al.*, 2006;Walter *et al.*, 2007). According to Elias&Sheiham (1999), aesthetics and communication are the most important factors in determining the value of oral health satisfaction, as well as the primary motivators for receiving prosthesis therapy. However, financial factor was found to influence patients' decisions to seek prosthetic treatment (Teofilo &Leles, 2007). This is probably why anterior teeth are extracted less than posterior teeth. This assumption needs further study.

This study, however, is subject to several limitations. The use of retrospective data does not favour proper assessment of risks such as furcation and mobility; instead must rely on the accuracy of clinical records performed by several clinicians in the past. It is also possible that accuracy was compromised with the heavy use of the conventional panoramic type of radiographic assessment. However, study found that there were no significant differences between a periapical and panoramic radiograph in assessing severe alveolar bone destruction (≥ 10mm from CEJ to bone crest) (Pepelassi & Diamanti-Kipioti, 1997). Semenoff *et al.* (2011) also found no significant differences between conventional and digitized periapical and panoramic radiographs for assessing advanced alveolar bone loss (≥ 6mm) in periodontitis. It was thus concluded that radiographic selection may not significantly influence the results of the current study.

In this study, neither diabetics nor smokers were excluded. This may have an impact on the results of this study, as both of these variables may increase the likelihood of periodontitis progression throughout maintenance (Costa *et al.*, 2013;Matuliene *et al.*, 2008). To analyze both factors, a univariate binary logistic regression analysis was performed. The results of the analysis reveal that smokers and diabetics have an elevated risk of periodontitis progression in hopeless and adjacent teeth, but statistically were not significant (Table 6). The insignificant results of smoker and diabetes within this study could be attributed to the small sample size of those factors. Furthermore, regular maintenance treatment could be a contributing factor as well. Fisher *et al.* (2008) found that both current smokers and non-smokers with chronic periodontitis who got regular maintenance treatment seemed to be able to stop the progressive destruction of periodontal tissue. Similar to the current study, their patients received maintenance therapy every 3 to 4 months.

In addition, evaluation of dental plaque was not included due to inconsistency in the assessment, especially for the hopeless tooth. This can influence the outcome of the present study, as the dental biofilm is one of the etiological factors for periodontitis (Kornman & Loe, 1993). The reasons for the inconsistency of plaque assessment of the hopeless tooth cannot be identified. Assumption was related to the fact that once a tooth is diagnosed as hopeless, it may be considered irrational to treat and therefore a complete assessment was not done. However, due to intensive maintenance care at an average of three times per year, patients within this study are expected to have an overall lower plaque score. Unfortunately, this cannot be proven.

Moreover, certain hopeless tooth (mandibular incisors) suffered from occlusal trauma were stabilized with direct composite splints. Studies have found that under regular periodontal maintenance, splinting of the hopeless mandibular incisors can stabilize the periodontal health and prolong survival (Graetz *et al.*, 2019; Sonnenschein *et al.*, 2017). However, a recent systematic review failed to draw a definitive conclusion on the efficacy of splint. The review concludes that the procedure does not improve survival of the mobile hopeless tooth, especially in patients with advanced (Stage IV) periodontitis (Dommisch *et al.*, 2021). Lastly, the reasons for hopeless tooth extraction were not clear. The intention to retain or extract the tooth may have been influenced by the clinicians' treatment philosophies.

Conclusion

Within the limitations of this study, the results suggest that periodontal therapy with a regular maintenance at an average of 4-month intervals favours retention of the hopeless tooth in periodontitis patients with no significant impact on the clinical periodontal parameters of the adjacent tooth.

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Conflict of interest

The authors declare no conflict of interest.

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