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Retrospective study of teeth with a poor prognosis following non-surgical periodontal treatment

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Abstract

Aim: The aim of this retrospective study was to assess teeth with a poor prognosis and the proximal periodontium of adjacent teeth, and to identify the risk factors associated with the loss of teeth with a poor prognosis following non-surgical periodontal treatment.

Materials and Methods: Teeth with a poor prognosis ($n = 113$), teeth adjacent to those of poor prognosis ($n = 105$) and non-adjacent teeth ($n = 51$) were evaluated in 25 non-smoking patients who had received supportive periodontal treatment for 5–16 years following non-surgical periodontal treatment at a university hospital.

Results: Probing pocket depth (PPD), percentage of alveolar bone loss, presence of tooth mobility and bleeding on probing in all teeth improved significantly after treatment. Logistic regression analysis showed that loss of teeth with a poor prognosis depended on the initial deepest PPD, tooth mobility and multi-rooted tooth.

Conclusions: Teeth with a poor prognosis did not affect the proximal periodontium of the adjacent teeth, and progression of periodontal disease in these teeth and adjacent teeth can be prevented by non-surgical periodontal treatment in non-smokers. The risk factors for loss of teeth with a poor prognosis were the initial deepest PPD, tooth mobility and multi-rooted tooth.

Key words: alveolar bone loss; periodontal disease; prognosis; tooth loss

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Dental caries and periodontal disease are the principal causes of tooth loss (Cahen et al. 1985, Kay & Blinkhorn 1986, Aida et al. 2006). Extraction of teeth is increasingly performed due to advanced periodontal disease; periodontally involved teeth are targeted for extraction based upon criteria that have been established generally without scientific evidence (Saadoun 1981, Yulzari 1982, Ibbott 1986, American Academy of Periodontology 2003). These ''strategic extractions'' of teeth with a poor prognosis are performed where there is advanced attachment loss or furcation involvement, for example, to prevent destruction of the adjacent proximal periodontium (American Academy of Periodontology 2000a, b), and to assist with placement of dental implants (American Academy of Periodontology 2003). However, even if teeth are diagnosed to have a poor prognosis, there are patients who prefer to retain these teeth rather than have them extracted (DeVore et al. 1988).

Conflict of interest and source of funding statement

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It has been reported that the retention of teeth with a poor prognosis has no effect on the proximal periodontium of adjacent teeth when periodontal maintenance is performed following surgical treatment (DeVore et al. 1988, Wojcik et al. 1992, Machtei & Hirsch 2007). In the absence of periodontal treatment, the retention of teeth with a poor prognosis has a destructive effect on the periodontium of the adjacent teeth (Machtei et al. 1989). However, little information is available regarding the long-term outcome of teeth with a poor prognosis during periodontal maintenance following non-surgical periodontal treatment.

A key component of treatment planning is the assignment of prognoses to individual teeth. Prognosis depends on tooth type (Chace & Low 1993), tooth mobility (Chace & Low 1993, McGuire & Nunn 1996, Nieri et al. 2002), alveolar bone height (Albandar 1990, McGuire & Nunn 1996, Nieri et al. 2002, Muzzi et al. 2006), the size of the infrabony defect (Nieri et al. 2002), probing pocket depth (PPD) (Chace & Low 1993, McGuire & Nunn 1996, Nieri et al. 2002, Matuliene et al. 2008), furcation involvement (Chace & Low 1993, McGuire & Nunn 1996), IL-1 genotype (McGuire & Nunn 1996, 1999, Kornman et al. 1997) and smoking status (Nieri et al. 2002, Fardal et al. 2004). However, the risk factors associated with the loss of teeth with a poor prognosis are not well documented.

The aim of this retrospective study was to assess teeth with a poor prognosis, the status of the periodontium of teeth adjacent to teeth with a poor prognosis and to identify the risk factors associated with the loss of teeth with a poor prognosis during maintenance following non-surgical periodontal treatment.

Materials and Methods

Study population

A retrospective study was conducted based on records of adult patients treated at the Department of Preventive Dentistry, Okayama University Hospital, Okayama City, Japan, between 1991 and 2007. Patients were included in the study if they were diagnosed with chronic periodontitis at their first visit, had at least one tooth with a poor prognosis, an adjacent tooth that did not have a poor prognosis, and a non-adjacent tooth that was located in the contra-lateral area of the adjacent teeth, and had received non-surgical periodontal treatment, followed by supportive periodontal treatment (SPT) for a period of at least 5 years. Individuals with systemic diseases and smokers were excluded.

Definition of poor prognosis

Teeth were defined as having a poor prognosis based on the following modified criteria (Takane et al. 2005), whereby two of the requirements had to be fulfilled: (1) loss of over 75% of alveolar bone support; (2) deepest PPD $\geq$ 8 mm; (3) class II or III furcation involvement; and (4) class III mobility when the tooth is moved by a force $<$0.49 N (Miyaura et al. 1999). A total of 113 teeth with a poor prognosis from 25 adult subjects (17 females, eight males; mean age, 52.5 $\pm$ 10.5 years; range, 40–70 years), who had received SPT for an average of 7.8 $\pm$ 2.3 years, were evaluated.

Periodontal treatment

All patients had received non-surgical periodontal treatment consisting of oral hygiene instructions, supra- and sub-gingival scaling and root planing, removal of sub-gingival plaque and professional tooth brushing. During SPT (1-h appointment), oral examination, oral hygiene instructions, supra- and sub-gingival scaling and root planing, removal of sub-gingival plaque and/or professional tooth brushing were performed by the clinician, whenever necessary. The frequency of recall visits was determined by the patient's periodontal condition and oral hygiene status at 1–3-month intervals (mean number of recall visits per year, 7.4 $\pm$ 3.4). The decision to extract or maintain the teeth with a poor prognosis was left to the patient after dentists informed them of the status of the teeth.

Demographic and clinical measures for patient-based analysis

Patient information, including gender, age, number of teeth present, full-mouth PPD, and full-mouth clinical attachment level (CAL) at six sites on each tooth (in millimetres), tooth mobility, plaque scores (O'Leary et al. 1972) and bleeding on probing (BOP) at six sites on each tooth in the whole mouth, was obtained from their records.

Clinical measures for tooth-based analysis

A tooth with a poor prognosis and an adjacent tooth that did not have a poor prognosis were identified from patient records. A non-adjacent tooth was selected randomly from the contra-lateral side. For tooth-based analysis, the deepest and mean PPD, deepest and mean CAL, presence or absence of tooth mobility, presence or absence of dental plaque, presence or absence of BOP, time of tooth loss, status of crown, connected crown or abutment tooth and history of repeated periodontal abscess formation during SPT were determined for the three types of teeth. The following radiographic evaluation was performed for each tooth.

Radiographic evaluation

Full-mouth intra-oral radiographs were used to assess furcation involvement, vertical bone loss, crown–root ratio, multi- *versus* single-rooted tooth and root canal treatment status for the three types of teeth. Radiographs were taken by radiologists using the long-cone paralleling technique (Asahi X-ray unit GX-60N, Asahi Roentgen International, Kyoto, Japan) (Tsuneishi et al. 2005). Kodak DF-57 films (Eastman Kodak, Rochester, NY, USA), which were automatically developed and fixed, were used in this study. Changes in radiographic alveolar bone height for each type of teeth were determined by comparing the initial visit with the most recent visit. The average time interval between the two radiographs was 8.0 $\pm$ 2.4 years. The amount of alveolar bone loss (%) was determined from scanned images using mathematical morphology software (WinROOF, Mitani Co., Fukui, Japan). The intra-alveolar root length (defined as the distance from the apex to the highest point on the alveolar margin) and the total root length (defined as the distance from the apex to the proximal cemento-enamel junction parallel to the long axis of the teeth) were measured to determine bone loss of individual teeth. Because the distance between the alveolar bone crest and cemento-enamel junction varies (Heins et al. 1988), 1.5 mm was subtracted from the total root length for the calculation (Demiralp et al. 2003).

Statistical analysis

For patient-based analysis, full-mouth mean PPD and CAL were calculated for each patient. The tooth mobility (%) per subject was calculated as the ratio of number of mobile teeth to the total number of teeth present. Percentage of bleeding sites to total sites was calculated in each subject.

We used a Wilcoxon test and a χ^2 test to assess significant differences ($p < 0.05$) between pre- and post-treatment data for patient- and tooth-based analysis. Comparisons between teeth adjacent to retained teeth with a poor prognosis and teeth adjacent to extracted teeth with a poor prognosis, and between adjacent and non-adjacent teeth were made by the Mann–Whitney *U*-test. A χ^2 test was used to assess significant differences between retained and extracted teeth with a poor prognosis in various clinical parameters. A backward, stepwise logistic regression analysis was performed to determine the optimal model for the prediction of teeth with a poor prognosis that should be extracted, using the following variables: initial vertical bone loss, crown–root ratio, multi- *versus* single-rooted tooth, crown status, connected crown status, root canal treatment status, abutment tooth, initial deepest PPD, initial deepest CAL, initial BOP, initial tooth mobility, initial amount of bone loss (%) and history of repeated periodontal abscess formation during SPT (Y/N) (da Silva et al. 2007). The odds ratio (ORs) and 95% confidence interval (CIs) were calculated. The logistic regression models were reviewed for goodness of fit and validated by means of the Hosmer–Lemeshow statistic (Saito et al. 2001, Ekuni et al. 2008). All analyses were performed using a software program (SPSS 15.0 J for Windows, SPSS Japan, Tokyo, Japan). Significant differences were defined as those for which $p<0.05$.

Results

The clinical parameters, except for number of teeth present and CAL, improved significantly post-treatment compared with those before treatment (Table 1).

The mean number of teeth with a poor prognosis per patient was 4.5 ± 2.8 (range: 1–13). Thirty-seven out of 113 teeth considered to have a poor prognosis at the initial visit were subsequently lost more than 1 year later (mean: 5.0 ± 4.0 years) and 76 teeth were retained. The mean period of follow-up from tooth extraction to the last examination was 3.8 years (SD: 2.3) (range: 3 months to 7.3 years). PPD, bone loss, number of mobile teeth, plaque score, and number of BOP-positive teeth in all teeth assessed improved significantly with treatment ($p<0.05$) (Table 2). CAL decreased after the treatment in adjacent teeth ($p<0.001$).

Table 3 shows the mean change (pre-treatment minus post-treatment) of PPD, CAL, and bone loss in teeth adjacent to teeth with a poor prognosis that were retained or extracted teeth during the maintenance period. There were no significant differences in PPD, CAL, and bone loss between the two tooth types.

The mean changes (pre-treatment minus post-treatment) of PPD, CAL, and bone loss in adjacent teeth and non-adjacent teeth are shown in Table 4. The decrease of PPD in the adjacent teeth was greater than that in the non-adjacent teeth ($p<0.05$).

The characteristics of retained *versus* extracted teeth with a poor prognosis are

Table 1. Clinical indices at pre- and post-treatment examinations (patient based)

	Pre-treatment (mean ± SD)	Post-treatment (mean ± SD)	p^*
Number of teeth present	24.7 ± 3.4	22.3 ± 4.0	<0.001
Probing pocket depth (mm)	3.33 ± 0.86	2.37 ± 0.62	<0.001
Clinical attachment level (mm)	3.69 ± 1.08	3.75 ± 1.17	0.757
% of number of mobile teeth	35.4 ± 27.7	21.2 ± 19.9	0.014
O'Leary's plaque control record (%)	32.2 ± 21.4	14.7 ± 18.2	<0.001
% of sites with bleeding on probing	37.9 ± 21.8	11.4 ± 12.3	<0.001

*Wilcoxon tests were performed.

Table 2. Clinical measures for retained teeth with a poor prognosis, and adjacent and non-adjacent teeth (tooth-based)

	Type of teeth	Pre-treatment	Post-treatment	p
Probing pocket depth (mm)	Poor prognosis ($n=76$)	4.26 ± 1.30*	3.21 ± 1.72	<0.001†
	Adjacent ($n=105$)	3.35 ± 1.15	2.26 ± 0.86	<0.001†
	Non-adjacent ($n=51$)	3.03 ± 1.23	2.35 ± 0.92	<0.001†
Clinical attachment level (mm)	Poor prognosis ($n=76$)	5.02 ± 1.72	5.85 ± 2.52	<0.001†
	Adjacent ($n=105$)	3.81 ± 1.36	3.72 ± 1.62	<0.001†
	Non-adjacent ($n=51$)	3.50 ± 1.61	3.79 ± 1.86	<0.001†
Bone loss (%)	Poor prognosis ($n=76$)	82.8 ± 14.1	74.3 ± 18.0	<0.001†
	Adjacent ($n=105$)	60.3 ± 19.3	52.6 ± 17.3	<0.001†
	Non-adjacent ($n=51$)	52.2 ± 17.5	49.5 ± 18.4	<0.001†
Presence of tooth mobility (number)	Poor prognosis ($n=76$)	45	27	0.003‡
	Adjacent ($n=105$)	45	26	0.006‡
	Non-adjacent ($n=51$)	20	10	0.030‡
Teeth with dental plaque (number)	Poor prognosis ($n=76$)	48	31	0.006‡
	Adjacent ($n=105$)	68	31	<0.001‡
	Non-adjacent ($n=51$)	24	10	0.003‡
Presence of bleeding on probing (number)	Poor prognosis ($n=76$)	58	13	<0.001‡
	Adjacent ($n=105$)	75	27	<0.001‡
	Non-adjacent ($n=51$)	29	8	<0.001‡

*Mean ± SD.
†Wilcoxon tests were performed.
‡χ^2 tests were performed.

Table 3. Mean annual change in probing pocket depth (PPD), clinical attachment level (CAL), and bone loss of teeth adjacent to retained and extracted teeth with a poor prognosis (pre-treatment minus post-treatment)

	Adjacent teeth of retained teeth with a poor prognosis ($n=86$) (Mean ± SD)	Adjacent teeth of extracted teeth with a poor prognosis ($n=19$) (Mean ± SD)	p^*
PPD (mm/year)	0.16 ± 0.16	0.14 ± 0.18	0.609
CAL (mm/year)	0.02 ± 0.27	0.003 ± 0.22	0.569
Bone loss (%/year)	1.59 ± 1.72	0.83 ± 2.08	0.083

*Mann–Whitney *U*-tests were performed.

Table 4. Mean annual change in probing pocket depth (PPD), clinical attachment level (CAL) and bone loss of adjacent teeth and non-adjacent teeth (pre-treatment minus post-treatment)

	Adjacent teeth ($n=105$) (Mean ± SD)	Non-adjacent teeth ($n=51$) (Mean ± SD)	p^*
PPD (mm/year)	0.16 ± 0.18*	0.09 ± 0.15	0.012
CAL (mm/year)	0.01 ± 0.23	− 0.05 ± 0.18	0.082
Bone loss (%/year)	0.96 ± 2.03	0.35 ± 1.41	0.052

*Mann–Whitney *U*-tests were performed.

Table 5. Characteristics of retained *versus* extracted teeth with a poor prognosis

	Retained	Extracted	p^*	Odds ratio (confidence interval)
Furcation involvement				
+	28	18	0.231	1.62 (0.73–3.60)
−	48	19		
Vertical bone loss				
+	60	32	0.334	1.71 (0.57–5.09)
−	16	5		
Poor crown–root ratio (> 1)				
+	4	3	0.556	1.59 (0.34–7.49)
−	72	34		
Multiroot				
+	36	20	0.505	1.31 (0.60–2.87)
−	40	17		
Crown teeth				
+	62	29	0.687	0.82 (0.31–2.17)
−	14	8		
Connected crown				
+	7	2	0.483	0.56 (0.11–2.86)
−	69	35		
Root canal treatment				
+	16	15	0.029	2.56 (1.09–6.03)
−	60	22		
Abutment teeth				
+	7	5	0.486	1.54 (0.45–5.23)
−	69	32		
PPD				
⩾8 mm	27	22	0.016	2.66 (1.19–5.97)
< 8 mm	49	15		
BOP				
+	68	34	0.684	1.33 (0.33–5.35)
−	8	3		
Tooth mobility				
+	45	33	0.001	5.68 (1.83–17.7)
−	31	4		
Bone loss (%)				
⩾75	54	33	0.032	3.36 (1.06–10.6)
< 75	22	4		
History of repeated periodontal abscess formation during maintenance				
+	28	20	0.082	2.02 (0.91–4.48)
−	48	17		

$^*\chi^2$ tests were performed.

shown in Table 5. Among teeth that were considered to have a poor prognosis, there were significant differences in root canal treatment, PPD, tooth mobility and bone loss between those that were extracted and those that were retained.

A backward, stepwise logistic regression model showed that loss of teeth with poor prognosis depended on the initial deepest PPD (OR: 1.37; 95% CI: 1.10–1.70) ($p = 0.005$), tooth mobility (OR: 10.36; 95% CI: 2.85–37.70) ($p < 0.001$) and multi-rooted tooth (OR: 3.19; 95% CI: 1.21–8.43) ($p = 0.020$).

Discussion

The results of this study suggest that retention of teeth with a poor prognosis had little effect on the proximal bone loss around adjacent teeth in the patients who received SPT. There were no significant differences in the mean annual changes of bone loss between teeth adjacent to retained teeth with a poor prognosis and teeth adjacent to extracted teeth with a poor prognosis, and between adjacent and non-adjacent teeth (Table 3). The periodontal status of teeth with a poor prognosis and adjacent teeth significantly improved after non-surgical periodontal treatment and SPT (Table 2), and the results suggest that the teeth were clinically stable. It was reported that teeth with a poor prognosis that are retained do not significantly affect the proximal periodontium of adjacent teeth following surgical periodontal treatment (DeVore et al. 1988, Wojcik et al. 1992, Machtei & Hirsch 2007). These results suggest that surgical or non-surgical periodontal treatment combined with SPT may not negatively affect teeth with a poor prognosis and their adjacent teeth.

The American Academy of Periodontology recommends that tooth extraction should be performed at the appropriate phase of periodontal treatment for ridge preservation for future prosthetic appliances and/or implants (American Academy of Periodontology 2003). Many dentists prefer extraction of teeth with a poor prognosis and replacement with implants (Davarpanah et al. 2000). However, even if teeth are diagnosed as having a poor prognosis, some patients prefer to retain these teeth rather than extracting them (DeVore et al. 1988). Our data provide evidence that retention of teeth with a poor prognosis is not necessarily detrimental to patients.

Sixty-seven per cent of teeth with a poor prognosis were retained without causing any damage to the surrounding periodontal tissues over time. This suggests that the criteria for poor prognosis given by Takane et al. (2005) are optimistic. Our data may help develop a better definition of prognosis severity, including the following concomitant parameters: PPD $\geq$ 8 mm, tooth mobility and multiple roots.

Thirty-three per cent of teeth with a poor prognosis were extracted in this study. In the other studies, 11% (follow-up: 6.7 years) (Checchi et al. 2002), 43% (4 years) (Machtei et al. 1989), 48% (4.4 years) (Machtei & Hirsch 2007), 67% (9 years) (Fardal et al. 2004), 80% (6 years) (Becker et al. 1984), and 100% (8 years) (McGuire 1991) of teeth with a poor prognosis were extracted following surgical periodontal treatment. Our data were in agreement with the range of other studies, although the sample size or methods of periodontal treatment differed.

In the logistic regression analysis, initial deepest PPD, tooth mobility and multi-rooted tooth were found to be independent predictors for extraction of teeth with a poor prognosis. Potential prognostic factors for tooth loss include tooth type, tooth mobility, bone level, infrabony bone height, PPD and furcation involvement (Chace & Low 1993, McGuire & Nunn 1996, Nieri et al. 2002, Fardal et al. 2004, Muzzi et al. 2006, Matuliene et al. 2008). For long-term survival of teeth with a poor prognosis with multiple roots or furcation involvement, surgical treatment may be helpful because a 10-year survival rate of 93–99% has been reported (Carnevale et al. 1998).

In this study, the decision to extract or maintain teeth with a poor prognosis was left to the patient after dentists informed them of the status of the teeth. Because we did not have enough evidence on the effect of retention of teeth with a poor prognosis on the adjacent periodontal tissue, we could not strongly recommend extraction to patients (in fact, the results of this study suggest that retained teeth with a poor prognosis have little effect on the adjacent periodontal tissue). Instead, we explained the periodontal status to the patients as clearly as possible. This decision was consistent with that of a previous study (Machtei & Hirsch 2007), which examined the effect of retention of teeth with a poor prognosis on the adjacent alveolar bone following periodontal surgery.

However, it should be realized that, in the present study, the reason for tooth loss remains unknown as it does in other retrospective studies on teeth with a poor prognosis (DeVore et al. 1988, Wojcik et al. 1992, Matuliene et al. 2008). Therefore, risk factors such as multi-rooted teeth (which are posterior and not an aesthetically important) and tooth mobility (which results in inconvenience for the patient) might be explained only by the patient's decision and not necessarily by periodontal issues/factors.

A meta-analysis demonstrated that both scaling and root planing alone, and scaling and root planing combined with a flap procedure are effective methods for the treatment of chronic periodontitis in terms of attachment level gain and reduction in gingival inflammation (Heitz-Mayfield et al. 2002). In teeth with deep pockets, surgical treatment results in greater PPD reduction and clinical attachment gain (Carnevale et al. 1998). In the present study, the mean PPD of those teeth with a poor prognosis decreased after non-surgical periodontal treatment, but loss of attachment was observed. Surgical treatment may be useful to help improve the PPD and CAL of teeth with a poor prognosis.

The results of this retrospective study suggest that teeth with a poor prognosis that were retained did not affect the depth of adjacent periodontal defects. However, the present study has limitations with respect to the small sample size and the retrospective design. Further clinical trials with a large sample size are required to confirm the data and conclusions of the present study. In addition, the statistical procedure used, using a different number of teeth in different patients to increase the data, might have resulted in a statistical bias and some important patient-related risk factors could have been ignored. Although known patient-related risk factors such as smoking (Eickholz et al. 2008) or diabetes mellitus (Faggion et al. 2007) were excluded from the study, unknown factors might have been involved in the risk of tooth loss. Further studies using one tooth with a poor prognosis, one tooth adjacent to that with a poor prognosis and one non-adjacent tooth from each subject are required to make the conclusions more credible.

In conclusion, teeth with a poor prognosis had no effect on the proximal bone height of adjacent teeth in non-smokers. Increases in PPD, bone loss, tooth mobility and BOP of these teeth and adjacent teeth can be prevented by non-surgical periodontal treatment. The risk factors for extraction of teeth with a poor prognosis were initial deepest PPD, tooth mobility and multi-rooted tooth.

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Clinical Relevance

Scientific rationale for the study: Surgical periodontal treatment, followed by SPT, is successful in retaining teeth with a poor prognosis. However, little information is available regarding the effect of non-surgical periodontal treatment on teeth with a poor prognosis.

Principal findings: The periodontal status of teeth with a poor prognosis and adjacent teeth significantly improved after non-surgical periodontal treatment. The risk factors for loss of teeth with a poor prognosis were initial deepest probing pocket depth, tooth mobility and multi-rooted tooth.

Practical implications: Non-surgical periodontal treatment is effective in treating teeth with a poor prognosis and preventing periodontal destruction of the adjacent teeth.