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Tooth loss in aggressive periodontitis after active periodontal therapy: patient-related and tooth-related prognostic factors

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Abstract

Objectives: To assess prognostic factors for tooth loss after active periodontal therapy (APT) in patients with aggressive periodontitis (AgP) at tooth level.

Material and methods: Eighty-four patients with AgP were re-evaluated after a mean period of 10.5 years of supportive periodontal therapy (SPT). Two thousand and fifty-four teeth were entered into the model. The tooth-related factors including baseline bone loss, tooth location and type, furcation involvement (FI), regenerative therapy, and abutment status, as well as time of follow-up and other patient-related factors were tested for their prognostic value at tooth level. Multilevel regression analysis was performed for statistical analysis to identify factors contributing to tooth loss.

Results: During SPT, 113 teeth (1.34 teeth per patient) were lost. Baseline bone loss, use as abutment tooth, tooth type, and maxillary location contributed significantly to tooth loss during SPT. Molars showed the highest risk for tooth loss after APT. Moreover, time of follow-up and the patient-related factor ''educational status'' significantly accounted for tooth loss at tooth level.

Conclusion: Baseline bone loss, abutment status, tooth location, and type as well as time of follow-up and educational status were detected as prognostic factors for tooth loss during SPT in patients with AgP at tooth level.

Key words: abutment tooth; aggressive periodontitis; bone loss; furcation involvement; supportive periodontal therapy (SPT); tooth loss

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Conflict of interest and source of funding statement

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Alveolar bone loss as a result of chronic or aggressive periodontitis (AgP) is one of the main causes of tooth loss (Ong 1998, Burt 2005). Several studies have demonstrated the effectiveness of periodontal therapy in arresting the progression of periodontal disease and in maintaining gingival health, thereby reducing the rate of tooth loss (Becker et al. 1984). Particularly for patients under supportive periodontal therapy (SPT), tooth loss quite rarely occurs (Eickholz et al. 2008). However, tooth loss is not distributed evenly among patients, but accumulates in distinct at-risk patients (Hirschfeld & Wasserman 1978, Chambrone et al. 2010). Some aspects characterizing periodontal at-risk patients are already known, although subject-level factors only partially explain the variation of tooth loss. A number of tooth-related factors have also been shown to impact tooth loss, among others alveolar bone loss (Dannewitz et al. 2006, Faggion et al. 2007, Pretzl et al. 2008), tooth mobility, degree of furcation involvement (FI) (McGuire & Nunn 1996, Dannewitz et al. 2006), tooth type (Muzzi et al. 2006), and tooth vitality (Faggion et al. 2007).

Nevertheless while analysing tooth-related factors, patient-related factors also have to be considered.

In general, it seems likely that risk factors have similar long-term influence on the prognosis of teeth after periodontal therapy in both chronic and AgP (Deas & Mealey 2010). As prevalence of AgP is low, data concerning treatment outcomes and long-term follow-up in this specific group of patients are limited. Few clinical studies report results for observation periods of 5 years (Lindhe & Liljenberg 1984, Wennström et al. 1986, Gunsolley et al. 1995). However, most of these studies have rather small sample sizes or case definitions are not consistent, which impedes a valid comparison of the available data. Results regarding tooth loss for observation periods longer than 5 years are scarce (Saxen et al. 1986). Therefore, the aim of the present study was to assess prognostic factors for tooth loss in patients with AgP 10 years after active periodontal therapy (APT) at tooth level.

Material and Methods

Patients

Patients with AgP, who had received APT at the Section of Periodontology, Department of Conservative Dentistry, Clinic for Oral, Dental and Maxillofacial Disease, University Hospital Heidelberg, from 1992 to 2005 were invited to participate in this study. In accordance with the specification of the European Periodontal Genetics Consortium (Kim et al. 2006, Fiebig et al. 2008), all patients fulfilled the following inclusion criteria:

- $\leq$ 36 years at baseline,
- panoramic radiograph or full-mouth set of periapical radiographs obtained before start of periodontal treatment and depicting interproximal bone loss of $\geqslant$50% at two or more teeth,
- a non-contributory medical history at baseline,
- $\geqslant$18 years at re-examination,
- completion of APT at least 5 years before start of this study.

The study was approved by the Institutional Review Board for Human Studies of the Medical Faculty of Heidelberg University (Application #033/2009). All patients were informed about possible risks and benefits as well as the procedures of the study and all gave written informed consent.

Clinical examination

Re-examination occurred from April 2009 to May 2010 and was conducted by an independent examiner (A. B.), who had never seen the patients before. It included medical history, family history of periodontal disease, and self-reported comprehensive smoking history [German Cancer Research Center (DKFZ)], whereby patients were categorized as current, former, and non-smokers (Lang & Tonetti 2003). Furthermore, dental status and periodontal status were assessed [probing pocket depth (PPD) along with vertical attachment levels (PAL-V) to the nearest 1 mm using a manual periodontal probe (PCPUNC 15; HuFriedy, Chicago, IL, USA) at six sites per tooth, bleeding on probing (BOP) after 30 s and suppuration on probing, assessment of FI (Hamp et al. 1975) at multirooted teeth using a Nabers probe marked in 3 mm increments (PQ2N; HuFriedy), gingival bleeding index (GBI) (Ainamo & Bay 1975), and plaque control record (PCR) (O'Leary et al. 1972).

Furthermore, a test for Interleukin (IL)-1 composite genotype using a test kit (GenoType PRT Parodontitis-Risiko-Test, Hain Lifescience GmbH, Nehren, Germany) was conducted and the body mass index (BMI) was calculated. Moreover, patients were asked for their educational status and classified into three groups: low ($<$9 years in school), moderate (apprenticeship, college), and high (university degree).

Evaluation of radiographs

Baseline radiographs (panoramic or full set of periapical radiographs) presented a mandatory inclusion criterion. Each radiographic image was scanned with a resolution of 600 $\times$ 1200 dpi (Epson Perfection 1269, Epson®, Meerbusch, Germany) and then transferred to a standardized personal computer (Friacom-PC, Friadent AG, Mannheim, Germany). Digital measurement of linear distances was performed using a computer program (Friacom®, Friadent AG) under standardized conditions in a darkened room. The following distances were measured at two sites (mesial and distal) for each tooth:

- CEJ to bony defect (BD) and
- CEJ to apex.

If the CEJ was destroyed by restorative treatment, the margin of the restoration was equalized to CEJ and taken as a landmark. Each tooth was then classified according to its alveolar bone loss into one of five categories: bone loss $<$20%, 20 to $<$40%, 40 to $<$60%, 60 to $<$80%, and 80% and more (Kim et al. 2006, Pretzl et al. 2008). In case of two different classes within one tooth, the tooth was characterized for analysis by the most severe category. All radiographs were measured by one independent examiner (R. C.) blinded for clinical measurements and for evaluation of patients' charts. To reduce variance, double measurements were taken in 10 patients and compared ($\kappa = 0.9$).

Evaluation of patients' charts

Retrospectively, each patient received a baseline diagnosis (localized or generalized AgP) according to the actual classification of periodontal diseases (Armitage 1999). Tooth loss during SPT, the main outcome variable of this study, was detected by comparing the dental status at re-evaluation after completion of APT with the dental status at re-examination in course of this study. Furthermore, the following tooth-related parameters were assessed from patients' charts:

- Jaw: maxilla or mandible.
- Tooth type: anterior, premolar, molar.
- FI: teeth were differentiated into (i) single-rooted teeth and multi-rooted teeth without (ii) or with (iii) baseline FI (Pretzl et al. 2008). Because of different examiners at baseline examination, analysis considering different degrees of FI could not be performed. Furthermore, not all patients' charts contained baseline information on different degrees of FI.
- Abutment tooth: according to baseline chart entries, each tooth was assigned to one of the following three groups: no abutment tooth (i), abutment tooth for fixed (ii), or removable (iii) prosthodontic constructions (Pretzl et al. 2008).

SPT

SPT encompassed the following elements for all patients at each appointment: assessment of GBI and PCR, re-instruction and re-motivation for effective individual plaque control, professional tooth cleaning with hand instruments, polishing of all teeth using a rubber cup and polishing paste, and

application of a fluoride gel. Probing pocket depth (PPD), PAL-V, and BOP were recorded at six sites per tooth. Sites exhibiting PPD of 4 mm and BOP as well as sites with PPD $\geqslant$ 5 mm were scaled subgingivally with a sonic scaler. For data analysis, mean values of GBI and PCR documented during SPT were calculated.

Statistical analysis

Tooth loss during SPT was defined as the main outcome variable. Statistical analysis was performed using different computer programs. Data entry and descriptive statistics were performed with one program (SPSS, Version 18; SPSS Inc., Chicago IL, USA). Logistic multilevel analysis was modelled by an independent statistician (P. R.) using the SAS software procedure GLIMMIX (SAS® version 9.1, SAS Institute, Cary, NC, USA). This generalized linear mixed regression was applied using a binomial distribution for the dichotomous dependent variable tooth loss and the logit as link function. For all analyses, the basic-level tooth was nested into the upper-level patient. For the classification variable patient, a random effect was estimated (SAS Institute Inc. 2006, Goldstein 1995). The main outcome event ''tooth loss'' was assumed to be binomial (yes/no).

The following independent patient-related variables were entered into the model in order to describe their effect on tooth level: sex, age, IL-1 composite genotype, diagnosis (localized or generalized AgP), SPT, smoking (never smoker *versus* active smoker and former smoker *versus* active smoker), BMI, insurance status, mean GBI during SPT, and educational status (low *versus* high and moderate *versus* high). In addition, tooth-related variables were tested for their impact on tooth level including relative amount of interproximal bone loss, tooth type (anterior *versus* premolar and molar *versus* premolar), jaw (mandible *versus* maxilla), FI (multi-rooted tooth with FI), abutment tooth (yes), and GTR/EMD during APT or SPT (no). The amount of interproximal bone loss relative to root length was recorded into five different categories (1: $<$20%, 2: $\geqslant$20/$<$40%, 3: $\geqslant$40/$<$60%, 4: $\geqslant$60/$<$80%, 5: $\geqslant$80%).

For each patient, the factor time of follow-up was entered into the model. Third molars were excluded from the analysis.

Results

Patients

A total of 174 patients with localized or generalized AgP, which were treated at the Section of Periodontology at the University Hospital Heidelberg between the years 1992 and 2005 who matched the inclusion criteria, could be detected retrospectively. Ninety of these patients were not able or willing to be re-examined. Finally, 84 of 174 patients participated in the study, which results in a responder rate of 48.3%. At initiation of therapy, patients were aged 20–36 years (mean age 30.8 $\pm$ 4.1 years). The overall proportion of female patients in this study was 81.0%. In 13 cases (15.5%), localized AgP was diagnosed, whereas 71 subjects met the criteria for a generalized form of AgP. At the beginning of SPT, patients contributed a total of 2154 teeth to the analysis, which were evenly distributed to the maxilla (48.7%) and the mandible (Table 1). Mean number of teeth per subject was 25.64 $\pm$ 3.27 (third molars not included). 39.3% of the patients presented 28 teeth and only five (6.0%) patients showed 20 teeth or less. Anterior teeth accounted for 44.8% of all teeth, pre-molars for 27.9%, and molars for 27.3%. More than half of all teeth were single rooted (66.2%). Three hundred and two (41.5%) of the 728 multi-rooted teeth exhibited FI of various degrees. The majority of teeth (97.0%) were not used as an abutment tooth for any kind of prostheses. Sixty-five teeth served as abutment teeth for a fixed dental prosthesis (3.0%); none of the patients had a removable prosthesis. Radiographic bone loss could not be determined in four teeth, resulting in the measurement in a total of 2150 teeth. Most teeth exhibited a baseline interproximal bone loss between 20% and $<$40% (51.4%). Most severe bone loss ($\geqslant$80%) was observed only in a small number of teeth (1.4%). Forty-six teeth were treated with enamel matrix derivatives (EMD, 10 teeth) or guided tissue regeneration using bioabsorbable membranes (GTR, 36 teeth) during APT or SPT. The average re-evaluation period after APT was 10.5 years (5–17 years). Mean bleeding and plaque score during SPT were 3.9 $\pm$ 3.7% (range 0–21.5%) and 26.1 $\pm$ 14.2% (range 3.9–100.0%), respectively.

Tooth loss

Before initiation of periodontal therapy, patients had already lost 145 teeth (third molars not included). During APT, 53 teeth were extracted and further 113 teeth were lost during SPT, representing a mean total tooth loss of 3.7 per patient (before therapy: 1.73 teeth, during APT: 0.63 teeth, and during SPT: 1.34 teeth; 0.13 teeth/patient/year). However, tooth loss was not distributed evenly. Less than half of the patients exhibited tooth loss during the follow-up and only a few individuals lost more than three teeth (nine patients; Table 2). In Table 3, distribution of tooth loss is listed. Tooth loss occurred differently in relation to jaw, tooth type, and FI. Teeth were extracted more frequently during SPT if they were molars (68.14% of extracted teeth, which adds up to an extraction rate of 13.12% of all molars at start of SPT), located in the maxilla (64.6% and 6.97%, respectively), or multi-rooted teeth with FI (51.33% and 19.21%, respectively). Forty-five per cent of the extracted teeth exhibited interproximal baseline bone loss of $\geqslant$40% and $<$60%, and 31.0% of $\geqslant$60%. During SPT, 37.8% of teeth with bone loss of 60% and more at baseline were extracted. Figure 1 emphasizes the observation of a higher number of lost teeth in the upper molar region ($n = 48$); by contrast, no canines and only five premolars in the mandible were extracted during SPT.

Table 4 depicts the results of the multilevel regression analysis for patient-related and tooth-related factors influencing tooth loss during SPT at tooth level. The amount of baseline bone loss, use as an abutment tooth, location in the maxilla, and the factor molar were associated with higher risk for tooth loss after APT at a statistically significant level. The risk increased with an OR of 1.05 for each additional step in the baseline bone-loss categories ($p < 0.0001$). The effect amplified for use as abutment tooth, thereby increasing the risk for tooth loss with an OR of 3.21 ($p = 0.0459$). Location in the mandible showed a protective effect with an OR of 0.42 for tooth loss during SPT ($p = 0.0018$). The analysis revealed molars having the highest risk for tooth loss during SPT (OR of 5.38, $p = 0.0012$). Furthermore, with more

Table 1. Patient and tooth characteristics: distribution of teeth according to location, tooth type, furcation involvement, use as abutment tooth, and alveolar bone loss at baseline

	Total	Localized AgP	Generalized AgP
Patients (*n*; %)	84	13; 15.5%	71; 84.5%
Female sex (*n*; %)	68; 81.0%	9; 69.2%	59; 83.1%
Age in years (mean ± SD in years)	30.8 ± 4.1	28.1 ± 4.3	31.3 ± 3.8
Number of teeth at the beginning of SPT (*n*; mean ± SD per patient)	2154; 25.64 ± 3.27	344; 26.46 ± 1.98	1810; 25.49 ± 3.45
Follow-up time (range, mean in years)	5–17; 10.54	6–12; 10.40	5–17; 10.56
Jaw (*n*; mean ± SD per patient)			
Maxilla	1048; 12.48 ± 2.65	170; 13.08 ± 1.5	878; 12.37 ± 2.8
Mandible	1106; 13.17 ± 1.1	174; 13.38 ± 0.87	932; 13.13 ± 1.13
Tooth type (*n*; mean ± SD per patient)			
Anterior	966; 11.5 ± 1.3	154; 11.85 ± 0.55	812; 11.44 ± 1.39
Pre-molar	601; 7.15 ± 1.43	90; 6.92 ± 1.75	511; 7.2 ± 1.37
Molar	587; 6.99 ± 3.27	100; 7.69 ± 0.63	487; 6.86 ± 1.57
Furcation involvement (*n*; mean ± SD per patient)			
Single-rooted teeth	1426; 16.98 ± 1.87	221; 17 ± 1.47	1205; 16.97 ± 1.94
Multi-rooted teeth without FI	426; 5.07 ± 2.9	96; 7.38 ± 2.14	330; 4.65 ± 2.83
Multi-rooted teeth with FI	302; 3.6 ± 2.48	27; 2.08 ± 1.8	275; 3.87 ± 2.5
Abutment tooth (mean ± SD per patient)			
No abutment tooth	2089; 24.87 ± 4.6	337; 25.92 ± 3.43	1752; 24.68 ± 4.78
Fixed	65; 0.77 ± 2	7; 0.54 ± 1.94	58; 0.82 ± 2.02
Removable	0	0	0
Periodontal bone loss ($n = 2150$)			
$<20\%$ (*n*; %)	231; 10.74%	112; 32.84%	119, 6.58%
$\geqslant 20\%$ to $<40\%$ (*n*; %)	1106; 51.44%	193; 56.6%	913; 50.47%
$\geqslant 40\%$ to $<60\%$ (*n*; %)	614; 28.56%	31; 9.09%	583; 32.23%
$\geqslant 60\%$ to $<80\%$ (*n*; %)	170; 7.91%	4; 1.17%	166; 9.18%
$\geqslant 80\%$ (*n*; %)	29; 1.35%	1; 0.29%	28; 1.55%
Regenerative procedures during APT and SPT (*n*; mean ± SD per patient)			
GTR/EMD	46; 0.55 ± 1.33	3; 0.23 ± 0.83	43; 0.61 ± 1.4

AgP, aggressive periodontitis; APT, active periodontal therapy; EMD, enamel matrix derivatives; FI, furcation involvement; GTR, guided tissue regeneration; SD, standard deviation; SPT, supportive periodontal therapy.

time spent in SPT the risk for tooth loss was slightly enhanced and time of follow-up showed a statistically significant impact (OR of 1.02, $p = 0.0103$). The patient-related factor educational status proved to influence tooth loss significantly at the tooth level as well: teeth in patients with low educational level showed a greater risk of being lost during SPT than those with high educational status (OR of 21.04, $p = 0.0103$) or with moderate educational status (OR 4.21, $p = 0.0321$). Moreover, teeth in patients diagnosed with generalized AgP were at an increased risk (OR of 1.62). However, the difference was statistically not significant ($p = 0.6786$).

Table 2. Patient-based analysis of tooth loss during supportive periodontal therapy (SPT)

	Total	Localized AgP	Generalized AgP
No tooth loss (*n*; %)	44; 52.38%	12; 92.31%	32; 45.07%
1 tooth (*n*; %)	17; 20.24%	–	17; 23.94
2 teeth (*n*; %)	7; 8.33%	–	7; 9.86%
3 teeth (*n*; %)	7; 8.33%	1; 7.69%	6; 8.45%
4 teeth (*n*; %)	2; 2.38%	–	2; 2.82%
5 teeth (*n*; %)	3; 3.57%	–	3; 4.23%
6 teeth (*n*; %)	1; 1.19%	–	1; 1.41%
7 teeth (*n*; %)	1; 1.19%	–	1; 1.41%
8 teeth (*n*; %)	–	–	–
9 teeth (*n*; %)	1; 1.19%	–	1; 1.41%
10–15 teeth (*n*; %)	–	–	–
16 teeth (*n*; %)	1; 1.19%	–	1; 1.41%

AgP, aggressive periodontitis.

Discussion

Tooth loss during SPT

Given their susceptibility to disease, patients with AgP need to be considered at high risk for recurrent disease after therapy. Despite the increased risk for disease recurrence, there is evidence that attachment loss can be stabilized, after therapy, in patients with AgP (Saxen et al. 1986, Buchmann et al. 2002, Zucchelli et al. 2002, Kamma & Baehni 2003). Relating to chronic periodontitis, several studies demonstrated the effectiveness of periodontal therapy and long-term SPT in arresting the progression of disease, thereby reducing the rate of tooth loss. These studies unanimously found low rates for tooth loss during SPT. In relation to different observation periods reported in these trials, rates for tooth loss ranged from 0.05 teeth/patient/year (Chambrone & Chambrone 2006) to 0.3 teeth/patient/year (Tsami et al. 2009). As most studies included patients who showed chronic periodontitis or whose disease category was not described in detail, comparison with our data is difficult. However, we observed a similar rate of tooth loss in our sample (0.13 teeth/patient/year) compared with the majority of studies (0.09–0.15 teeth/patient/year) (McFall 1982, Wood et al. 1989,

Table 3. Tooth loss during supportive periodontal therapy (SPT) in relation to location, tooth type, furcation involvement, use as abutment tooth, and alveolar bone loss at baseline

	Total	Localized AgP	Generalized AgP
Number of teeth after APT (*n*; mean ± SD; % of teeth at start of SPT)	113; 1.35 ± 2.42; 5.25%	3; 0.23 ± 0.83; 0.87%	110; 1.55 ± 2.56; 6.08%
Jaw (*n*; %; % of teeth at start of SPT)			
Maxilla	73; 64.6%; 6.9%	3; 100%; 1.76%	70; 63.64%; 7.97%
Mandible	40; 35.4%; 3.62%	0	40; 36.36%; 4.29%
Tooth type (*n*; %; % of teeth at start of SPT)			
Anterior	19; 16.81%; 1.97%	1; 33.33%; 0.65%	18; 16.36%; 2.22%
Pre-molar	17; 15.04%; 2.83%	0	17; 15.45%; 3.33%
Molar	77; 68.14%; 13.12%	2; 66.67%; 2%	75; 68.18%; 15.4%
Furcation involvement (*n*; %; % of teeth at start of SPT)			
Single-rooted teeth	34; 30.09%; 2.38%	1; 33.33%; 0,45%	33; 30%; 2.74%
Multi-rooted teeth without FI	21; 18.58%; 4.93%	1; 33.33%; 1.04%	20; 18.18%; 6.06%
Multi-rooted teeth with FI	58; 51.33%; 19.21%	1; 33.33%; 3.7%	57; 51.82%; 20.73%
Abutment tooth (*n*; %; % of teeth at start of SPT)			
No abutment tooth	102; 90.27%; 4.88%	3; 100%; 0.89%	99; 90%; 5.65%
Fixed	11; 9.73%; 16.92%	0	11; 10%; 18.97%
Removable	0	0	0
Periodontal bone loss (*n*; %; % of teeth at start of SPT)			
$<20\%$	3; 2.65%; 1.3%	0	3; 2.73%; 2.52%
$\geqslant 20\%$ to $<40\%$	24; 21.23%; 2.17%	3; 100%; 1.55%	21; 19.09%; 2.3%
$\geqslant 40\%$ to $<60\%$	51; 45.13%; 8.31%	0	51; 46.36%; 8.75%
$\geqslant 60\%$ to $<80\%$	29; 25.66%; 17.06%	0	29; 26.36%; 17.47%
$\geqslant 80\%$	6; 5.31%; 20.7%	0	6; 5.45%; 21.43%
Regenerative procedures during APT or PM (*n*; % of teeth at start of SPT)			
GTR/EMD	3; 6.52%	0	3; 2.73%; 6.89%

AgP, aggressive periodontitis; APT, active periodontal therapy; EMD, enamel matrix derivatives; FI, furcation involvement; GTR, guided tissue regeneration; SD, standard deviation; SPT, supportive periodontal therapy.

McLeod et al. 1998, Matthews et al. 2001, Jansson & Lagervall 2008, Pretzl et al. 2008). There are only few longitudinal studies reporting on tooth loss during SPT focusing on patients with AgP, formerly classified as early-onset periodontitis (Saxen et al. 1986, Gunsolley et al. 1995, Kamma & Baehni 2003). Results for tooth loss rate ranged from 0.11 (Saxen et al. 1986) to 0.2 teeth/patient/year (Kamma & Baehni 2003). Only Gunsolley et al. (1995) described a higher tooth loss rate (0.29 teeth/year), which might be explained by the fact that some patients in that study received no periodontal therapy and therefore might have lost more teeth annually (Gunsolley et al. 1995). In general, tooth loss in patients with AgP during SPT does not seem to differ markedly from patients with chronic periodontitis. Our data showed that tooth loss was not distributed evenly during SPT. Overall, more than half of the patients (52.4%) did not loose any teeth during the observation period. In the subgroup of patients diagnosed with localized AgP, this percentage was even significantly higher (92.3%). Only nine subjects (10.5%) lost more than three teeth. Among this group, one patient lost nine teeth (already missing 15 teeth before periodontal therapy) and another person 16 teeth (one tooth, respectively). Both were female, active smokers, and held a low or moderate educational status. Our observation coincides with previous studies revealing that only a minority of treated patients are responsible for the majority of tooth extractions during SPT (Chambrone et al. 2010).

Prognostic factors for tooth loss

At tooth level, enhanced baseline bone loss, use as an abutment tooth, location in the maxilla, and ''molar'' were associated with higher risk for tooth loss during the follow-up at a statistically significant level. Use as abutment tooth (OR = 3.21) and ''molars'' (OR = 5.38) deteriorate the prognosis of teeth after APT most notably. In contrast, location in the mandible showed a protective effect (OR = 0.42). The effect of FI failed to reach statistical significance in this model. However, influence of advanced FI might be masked as degrees of FI could not be reliably differentiated on the basis of the patient's baseline charts and were not further considered for analysis. These observations coincide with results of many previous studies including mostly patients with chronic periodontitis (Hirschfeld & Wasserman 1978, McFall 1982, Goldman et al. 1986, Wood et al. 1989, Chambrone & Chambrone 2006, Dannewitz et al. 2006, Pretzl et al. 2008, Chambrone et al. 2010).

Because of the fact that results concerning prognostic factors for tooth loss in AgP are missing, only comparison with ChP is feasible. Similar to our study, tooth type (molar) represents a statistically significant risk factor for tooth loss in long-term studies with samples of mostly ChP patients (Muzzi et al. 2006, Faggion et al. 2007, Pretzl et al. 2008). Numerous factors contribute to an inferior prognosis in molars after APT. Among others, morphological features and anatomy impede accessibility for individual oral hygiene and professional root debridement. Use as abutment tooth is also positively associated with tooth loss during SPT in several other studies (Yi et al. 1995, Lulic et al. 2007, Pretzl et al. 2008). Despite regular maintenance, 5–8% of abutment teeth in fixed constructions were extracted during a mean follow-up time of 10 years

(Yi et al. 1995, Lulic et al. 2007). Pretzl et al. (2008) described a doubled rate of tooth loss over 10 years in fixed bridgework in relation to teeth not used as abutments. This distinctiveness might be explained by the reduced accessibility for cleaning and thus risk for re-infection and progression of disease. Finally, preparation of a tooth as an abutment increases the risk of endodontic complications (Goodacre et al. 2003, Lulic et al. 2007), which may also lead to tooth loss. Removable prostheses depict a factor enhancing the afore-mentioned effect (Pretzl et al. 2008). However, this effect could not be studied as none of the patients possessed a removable prosthesis.

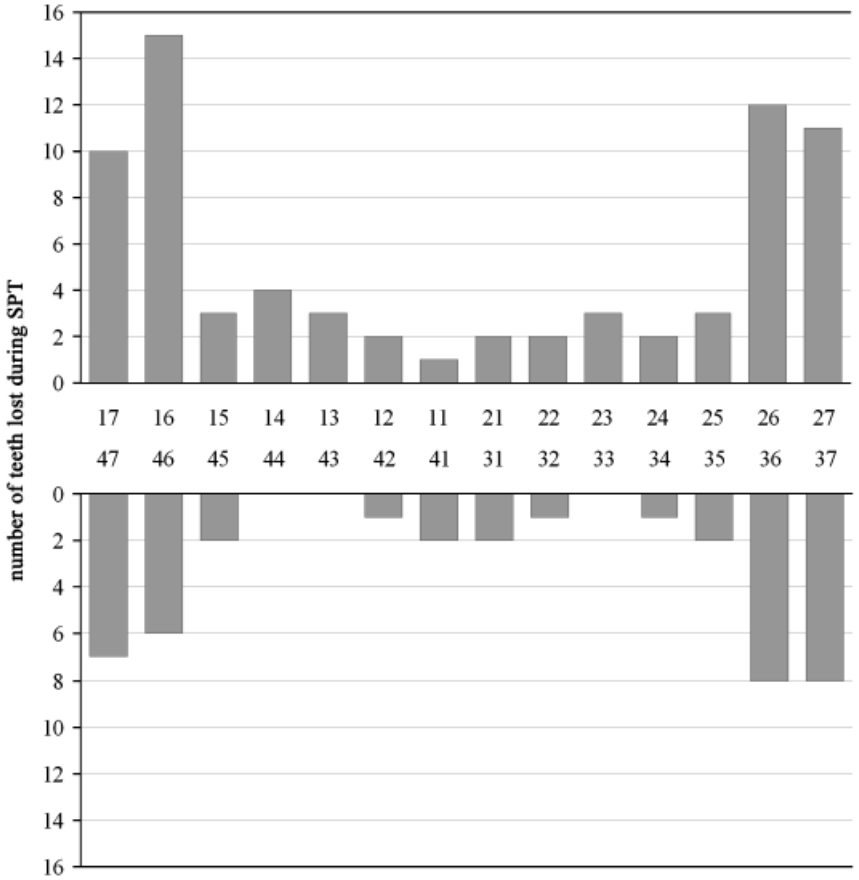

Fig. 1. Tooth loss during supportive periodontal therapy (SPT) according to tooth type.

Time of follow-up as well as low educational status of the patient negatively affected the prognosis of teeth after initial periodontal therapy at the tooth level as well. This coincides with the Study of Health in Pomerania including 3146 participants (Kocher et al. 2005), whose authors documented a low educational level as risk determinant for attachment and tooth loss. In general, tooth loss in adults is significantly influenced by the educational status of subjects, which was also reported in the survey of oral health in Germany (Schiffner et al. 2009). The value of this subject specific showed even greater association with tooth loss during SPT at a tooth rather than a patient-level analysis (RR of 3.74 *versus* OR of 21.04). In contrast, other patient-related factors failed to reach statistical significance in this model.

Bias

Tooth loss rarely occurs as a result of spontaneous exfoliation, but rather

Table 4. Logistic multilevel regression analysis: tooth loss during supportive periodontal therapy (SPT) related to specific parameters evaluated retrospectively

	Estimate	*p*	*t*-value	Odds ratio	95% CI
Intercept	− 16.6474	< 0.0001	− 4.29		
Female sex (yes)	− 0.5929	0.5068	− 0.66	0.55	0.10–3.18
Age (year)	0.1743	0.0926	1.68	1.19	0.97–1.46
Diagnosis (generalized AgP)	0.4813	0.6786	0.41	1.62	0.17–15.76
Smoking					
Non-smoker *versus* current smoker	− 0.7777	0.2476	− 1.16	0.46	0.12–1.72
Former smoker *versus* current smoker	− 1.2814	0.0879	− 1.71	0.28	0.06–1.21
Educational status					
Low *versus* high	3.0466	0.0103	2.57	21.04	2.05–215.5
Moderate *versus* high	1.4385	0.0321	2.15	4.21	1.13–15.68
Bone loss (classes)	0.0514	< 0.0001	5.44	1.05	1.03–1.07
Abutment tooth (yes)	1.1669	0.0459	2.00	3.21	1.02–10.09
Furcation involvement (multi-rooted tooth with FI)	0.3266	0.2844	1.07	1.39	0.76–2.52
Jaw (mandible)	− 0.8659	0.0018	− 3.13	0.42	0.24–0.72
Tooth type					
Anterior tooth *versus* premolar	− 0.5090	0.2272	− 1.21	0.60	0.26–1.37
Molar *versus* premolar	1.6826	0.0012	3.25	5.38	1.95–14.85
Regenerative procedure (no GTR/EMD)	0.9242	0.2147	1.24	2.52	0.59–10.84
Follow-up time	0.0207	0.0103	2.57	1.02	1.00–1.04

None of the following parameters were statistically significant: SPT, interleukin-1 composite genotype, mean gingival bleeding index during SPT, body mass index, insurance.

AgP, aggressive periodontitis; CI, confidence interval; FI, furcation involvement.

results from a provider's decision to extract a tooth; it has to be kept in mind that tooth survival data are inherently biased. Although all participants in this study were asked about reasons for tooth loss and patients' charts were scanned for it, often the causes for an extraction could not be obtained. Particularly in patients who quit treatment at the Section of Periodontology, reasons for tooth loss remained unsure. Therefore, it could not be differentiated whether a tooth was extracted for endodontic, periodontal, or other reasons. Furthermore, the patient's attitude regarding his or her teeth and the individual treatment philosophy of the dentist play an important role in the decision of extracting teeth (Zaher et al. 2005).

Conclusion

After completion of APT in patients with AgP, baseline bone loss, use as abutment tooth, tooth type (molar), location in the maxilla, time of follow-up, and educational status represent statistically significant prognostic factors at tooth level. On the basis of published data and our results, it seems likely that prognostic factors at tooth level have a similar long-term impact on both chronic periodontitis and AgP.

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Clinical Relevance

Scientific rationale for the study: Long-term retention of teeth in function is the ultimate goal of periodontal therapy. This study antecedes in detecting prognostic factors deteriorating the long-term retention of teeth after periodontal treatment in patients with AgP at the tooth level.

Principal findings: Tooth-related parameters significantly contributing to tooth loss during SPT were baseline bone loss, use as abutment tooth, and maxillary location. Molars showed the highest risk for tooth loss after APT. Patient-related parameters with a significant impact on tooth level were time of follow-up and educational status.

Practical implications: Dentists need to be able to discuss prognosis of teeth with their patients on a reliable basis.