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Effort and costs of tooth preservation in supportive periodontal treatment in a German population

Bernadette Pretzl[1], Denise Wiedemann[1], Raluca Cosgarea[1], Jens Kaltschmitt[1], Ti-Sun Kim[1], Hans-Joerg Staehle[1] and Peter Eickholz[2]

[1]Section of Periodontology, Department of Conservative Dentistry, Clinic for Oral, Dental and Maxillofacial Diseases, University Hospital Heidelberg, Germany; [2]Department of Periodontology, Center of Dental, Oral, and Maxillofacial Medicine (Carolinum), Hospital of the Johann Wolfgang Goethe-University Frankfurt/Main, Germany

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Abstract

Objectives: Assessment of effort (number of visits) and costs of tooth preservation 10 years after initiation of anti-infective therapy.

Material and Methods: Data of 98 patients who had received active periodontal treatment 10 years ago by the same examiner were analysed to gather information on effort and costs of supportive periodontal therapy (SPT). Clinical examination, interleukin-1 (IL-1) polymorphism test, smoking, search of patients' files (i.e. initial diagnosis), as well as a questionnaire on medical history and socioeconomic data were performed.

Statistical analysis was performed using multivariate linear regression analysis.

Results: During 10 years of SPT patients had 14.8 ± 7.4 visits. Number of visits was statistically significantly higher for individuals with a mean plaque control record ⩾24%. The number of subgingival scalings per tooth ranged from 0 to 14 (mean: 1.17). On tooth level several confounders could be identified: tooth type, initial bone loss, furcation involvement, abutment status, and previous regenerative surgery ($p \leqslant 0.003$).

Costs for therapy per tooth during SPT ranged from €1.21 to €404.72 with mean costs between €60.52 and €91.99. On tooth level the tooth type, initial bone loss, abutment status, furcation involvement, and previous regenerative surgery showed statistical significance ($p \leqslant 0.002$).

Conclusion: Costs for tooth retention via SPT are relatively low compared with alternatives (e.g. implants or bridgework) even in periodontally impaired teeth.

Key words: costs; long-term success after systematic periodontal therapy; periodontal risk factors; supportive periodontal therapy (SPT); tooth loss

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The aim of periodontal therapy is the long-term retention of natural teeth in a healthy, functional, aesthetically acceptable, and painless state (Hirschfeld & Wassermann 1978, Schweizerische Zahnärzte-Gesellschaft 2000). Particularly for patients under supportive periodontal therapy (SPT) attachment loss and tooth loss (Hirschfeld & Wassermann 1978, Checchi et al. 2002, Eickholz et al. 2008, Matuliene et al. 2008) occur quite rarely.

In two recent studies (Eickholz et al. 2008, Pretzl et al. 2008) we were able to explain a certain amount of tooth loss in patients treated for periodontitis 10 years previously by one experienced periodontist and could confound several risk factors, e.g. infrequent SPT, age, smoking, and individual oral hygiene. Further, on tooth level it was demonstrated that initial bone loss, tooth type (single-rooted, multi-rooted with or without furcation involvement), and abutment status have an impact on future tooth loss.

Up to this point the costs of SPT (and hereby tooth preservation) were often neglected in research. Although it has been suggested in the Fifth European Workshop on Periodontology, economic parameters are still rarely presented (Brägger 2005, Davies et al. 2005).

Conflict of interest and source of funding statement

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Therefore in our present analysis we intended to assess the costs of and patients' effort put into tooth retention during SPT compared with alternative procedures, i.e. insertion of fixed (bridgework) or removable prostheses or implants. Additionally, a second focus was set on socioeconomic factors, such as education and insurance status contributing to higher costs.

The aim of this study was to assess effort and costs of tooth retention by supportive periodontal treatment over 10 years after initiation of anti-infective therapy.

Material and Methods

Patients

All patients who fulfilled the following criteria were consecutively recruited 10 years ± 6 months after initiation of therapy for this study until 100 qualifying patients had been included:

- Periodontal treatment (anti-infective therapy with subgingival debridement under local anaesthesia and periodontal surgery if required) at the Section of Periodontology at the Department of Conservative Dentistry, Clinic for Oral, Dental, and Maxillofacial Diseases at the University Hospital Heidelberg beginning in October 1992 by the same trained periodontal specialist (P. E.).
- X-ray status obtained before periodontal treatment.

Data of two patients had to be excluded due to incomplete information.

The study was approved by the Institutional Review Board for Human Studies of the Medical Faculty of Heidelberg University (Application# 331/2002). All participating patients were informed about possible risks and benefits as well as the procedures of the study and all gave written informed consent.

Clinical examinations

The re-examinations performed by an independent examiner (B. P.) have been reported in detail in a previous paper (Eickholz et al. 2008). Thus, only a brief description of the clinical examinations is provided: gingival bleeding index (GBI; Ainamo & Bay 1975) and plaque control record (PCR; O'Leary et al. 1972), probing pocket depths (PPD) and vertical attachment levels (PAL-V) were assessed to the nearest 1 mm using a manual periodontal probe (PCPUNC 15; Hu-Friedy, Chicago, IL, USA) at six sites per tooth. Bleeding (BOP) and suppuration (SUP) were recorded 30 s after probing (Joss et al. 1994). In multirooted teeth the furcation involvement (Hamp et al. 1975) was assessed using a Nabers probe marked in 3 mm steps (PQ2N; Hu-Friedy). All patients were tested for interleukin-1 (IL-1) polymorphism (IL-1A −889, IL-1B +3953). Retrospectively, each patient was assigned a baseline diagnosis (e.g. generalized moderate chronic periodontitis) according to the actual classification of periodontal diseases (Armitage 1999).

Evaluation of radiographs

A detailed description of the radiographic analysis is given in another previous paper (Pretzl et al. 2008). Hence, just a brief description is given here. Before active periodontal treatment (subgingival debridement and periodontal surgery if required) complete sets of peri-apical radiographs of each patient were obtained.

Relative percentage bone loss was assessed at the most periodontally affected site of each tooth using a Schei ruler (Schei et al. 1959). Furthermore, at the inter-proximal site with the most severe bone loss of each tooth, the type of bone loss was characterized as horizontal or vertical (infrabony defect). At each infrabony defect site the depth of the infrabony component was measured to the next 0.1 mm using a loupe with 10-fold magnification (Scale loupe 10 ×, Peak, Tohkai Sangyo, Tokyo, Japan) (Eickholz et al. 1996). For each tooth it was assessed whether a double contour of the root could be detected. A double contour was interpreted as indicator for a mesial or distal root groove.

According to the clinical and radiographic findings each tooth was assigned to one of three prognostic groups (Checchi et al. 2002):

- *hopeless*: bone loss >75% or teeth that had at least two characteristics of the ''questionable'' category;
- *questionable*: bone loss ⩾50 and ⩽75% or the presence of an angular defect (infrabony component >2 mm) or furcation involvement;
- *good*: bone loss <50% and none of the criteria of the former category.

Radiographic assessments were performed by an independent examiner blinded for clinical measurements and therapy rendered (J. K.).

Evaluation of patients' charts

For each patient, it was documented whether he or she had attended SPT at the Section of Periodontology at the University Hospital Heidelberg regularly complying with the intervals that had been recommended. If a patient had extended the recommended SPT interval at least once by >100% he or she was assigned to the irregular SPT group (e.g. the recommended SPT interval was 6 months and the patient returned for SPT after 13 months) (Eickholz et al. 2008).

Additionally the total number of SPT was recorded for each patient including the amount of subgingival scalings per tooth over the period of 10 years. A tooth was re-instrumented during SPT when a pocket depth of 4 mm and BOP or a pocket depth of at least 5 mm were recorded.

A secondary focus was set on plaque. At every visit during SPT each tooth of a patient was gently air-dried and disclosed using Mira-2-Tone (Hager & Werken GmbH & Co. KG, Duisburg, Germany) to stain for the presence of plaque. Afterwards each stained tooth was cleaned professionally. The number of professional cleanings per tooth during the 10-year period was recorded as well.

SPT

SPT encompassed the following elements for all patients at each appointment:

(1) assessment of GBI and PCR as amount of positive (bleeding for GBI, plaque for PCR) in percentage of all assessed sites,
(2) re-instruction and re-motivation to effective individual plaque control,
(3) professional tooth cleaning with hand instruments and polishing of all teeth using rubber cups and polishing paste,
(4) application of a fluoride gel.

Twice a year a dental status and PPD were obtained at four sites per tooth. Thirty seconds after probing BOP was recorded. Sites exhibiting PPD = 4 mm and BOP as well as sites with PPD ⩾5 mm were scaled subgingivally.

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If a patient exhibited more than five to six sites that ought to be debrided subgingivally, repeated anti-infective therapy was recommended. From 1992 (when therapy of the first included patients was initiated) to 1999 assignment of SPT intervals was not performed according to strict criteria. SPT was provided to most patients at 3-month intervals during the first year of SPT and later on at 6-month intervals. Patients exhibiting ineffective plaque control (PCR > 35%) or with initial diagnosis of aggressive periodontitis (at that time: juvenile and rapidly progressive periodontitis) were usually seen four times a year for SPT (3-monthly intervals). From October 1999 the assignment of SPT intervals was performed according to the periodontal risk assessment (PRA) (Ramseier & Lang 1999, Lang & Tonetti 2003, Eickholz et al. 2008).

Interviews

A detailed questionnaire of the German Cancer Research Centre in Heidelberg containing information on smoking habits, marital status, education, self-reported medical history, and oral hygiene was conducted with the patient at the clinic after the dental re-examination. Each interview was carried out by the same dentist (B. P.).

German health system/costs of tooth retention

For most people health insurance is compulsory in Germany. There are two options of insurance systems: law-enforced and private health insurance. Law-enforced health insurance is narrowly controlled by the German government. Most people are obliged to take out law-enforced health insurance. Private health insurance can be chosen in some specific cases (e.g. self-employed persons, civil servants, and employees reaching a certain gross income threshold). In contrast to the government controlled system, private health insurance rates are based on the insured's risk profile, not on income. Private health insurance schemes provide more extensive cover, e.g. coverage of costs of SPT, whereas law-enforced insurance only accounted for removal of calculus twice a year until 2004 and once a year since then.

Calculation of costs

In Germany SPT is not covered by law-enforced insurance. SPT has to be paid for privately by all patients irrespective of insurance status. Thus, total costs of SPT throughout the 10 years were calculated according to the GOZ (''Gebührenordnung für Zahnärzte'': dentists' scale of charges and fees for privately insured patients in Germany) to the 2008 price level. In order to receive a comparable specification of costs, each single item was multiplied by 2.3, the factor used in accounting for therapy rendered to patients with state insurance. In Germany fees for patients with private insurance can be multiplied by a number of factors in the range of 1.0–3.5 depending on time and difficulty of the procedure rendered. Multiplication by a factor above 3.5 is also possible but not always compensated for by the insurance. The GOZ has not been adjusted to rising expenses since 1987. After 20 years without alignment dentists do not charge the basic fees (one-fold) but usually the 2.3-fold amount of the basic charges. Thus, all costs are calculated to the 2008 price level using 2.3-fold basic charges. To adjust the calculations we chose to multiply each item by 2.3 (minimum) and 3.5 (maximum within the coverage of insurances) irrespective of the factual costs.

Several factors had to be added up:

- Oral hygiene status (duration at least 25 min.) including plaque and gingival index, oral hygiene instructions: €25.87/39.32 (2.3/3.5); maximum once a year.
- For patients showing up more often reduced costs were added for each additional oral hygiene status (duration at least 15 min.) in accordance with the GOZ: 12.92/19.64€.
- Periodontal status (PPD and AL at four sites per tooth): €20.69/31.45.
- Application of an antimicrobial agent: €6.19/9.41.

The sum of these items was then multiplied with the number of visits per patient and divided by the number of teeth present. For each tooth the costs for professional supragingival cleanings (€1.40/2.13 each) and subgingival scalings (€14.23/21.63 each) during SPT were added. Thereby a price tag could be attached to an individual tooth.

Then, these costs were compared with costs of fixed bridgework or implant placement, including impressions, preparation of two neighbouring teeth, and insertion of bridgework; the dentist's fees for prosthetic rehabilitation amounted to €437.21. For materials and laboratory work, costs of approximately €1212.60 would have to be charged. This results in a total of approximately €1650 for bridgework compared with approximately €2050 for insertion of an implant: €635 dentist's fees, €218.40 for the implant itself, and approximately €1200 for materials and laboratory work. Both numbers depict the *minimum* costs not accounting for any additional procedures, e.g. sinus lifts and only multiplying each item by factor 2.3.

A cheaper alternative for replacement of one to several teeth would be a denture ranging from approximately €790 (one tooth replaced) to €960 (12 teeth replaced). Again, this depicts the *minimum* costs, only.

Statistical analysis

Three outcome variables were defined: (1) number of visits during SPT per patient, (2) number of scalings, and (3) costs per tooth during the 10 years of SPT. The patient was defined as the statistical unit. Statistical analysis was performed using one computer programme. Data entry as well as descriptive statistics and multilevel regression analysis were performed using SPSS (SPSS 15.0 for Windows, SPSS Inc., Chicago, IL, USA).

A linear multivariate regression was modelled to explain the variation of the number of SPT visits over 10 years.

For analysis of factors influencing number of scalings and costs per tooth during the 10 years of SPT multilevel regression analyses were calculated due to the fact that different patients contributed different numbers of teeth in need for re-instrumentation. For these analyses, the basic-level ''tooth'' was nested into the upper-level ''patient''. All patient effects were assumed to be random. The following independent patient-related variables were entered into the models: sex, age, IL-1 polymorphism, diagnosis, smoking, socio-economic factors, e.g. type of insurance (law-enforced/private) and education (< 9, 9–12, and > 12 years).

Third molars were excluded from the analysis.

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Results

Patients

A total of 145 patients had been consecutively invited to participate in the study according to the schedule of therapy initiation 10 years ± 6 months before. Forty-two of these patients were not able or not willing to have a re-examination. Accordingly the responder rate was 71%. Five further patients had to be excluded during analysis due to incomplete data.

Ninety-eight patients aged between 25 and 77 years (mean age 46.6 ± 10.3) at initiation of therapy with a total of 2249 teeth at the start of SPT participated in the re-examination. Most patients were of Caucasian European origin. Four patients were of Asian origin (two Vietnamese, one Chinese, and one Japanese), one patient was of North African heritage (Egyptian).

Detailed information on patients' characteristics is given in a companion paper (Eickholz et al. 2008). Additional information included in this study are presented in Table 1.

Costs

The mean number of visits per patient amounted to 14.83 ± 7.42 (Table 2): one of the patients did not show up once for a recall visit whereas the maximum of SPT rendered to a single individual in the 10-year study period was 32. The number of SPT was statistically significantly higher for individuals with a mean PCR ⩾ 24% ($p = 0.004$, Table 3). Gender, initial diagnosis, smoking, and IL-1β-polymorphism failed to have a statistically significant impact on number of recall visits. No statistically significant difference could be detected regarding insurance status ($p = 0.560$). Education only slightly failed to have a statistically significant influence on number of visits during SPT ($p = 0.06$). The mean number of recall visits for patients who showed up on a regular basis (Eickholz et al. 2008) was 19.78 ± 3.88, corresponding to an average of two visits per year; the minimum of visits per patient was 11.

Subgingival scalings per tooth ranged from 0 to 14 during the 10-year study period (mean: 1.17; Table 4). On patient level the number of re-instrumentations was, obviously, higher for patients showing up on a regular basis ($p < 0.001$), and patients exhibiting a PCR ⩾ 24% (median over all mean values during SPT) received less scalings than others although the PCR slightly failed statistical significance ($p = 0.066$). Information on number of scalings of all 2249 included teeth is given in Table 5.

As can be seen in Table 6, on a tooth level several confounders had a statistically significant impact on number of re-instrumentations: tooth type ($p = 0.001$), initial bone loss ($p < 0.001$), furcation involvement ($p = 0.003$), abutment status ($p = 0.002$), and previous regenerative surgery ($p < 0.001$). In average, molars received 2.41 scalings in 10 years, premolars 1.01, and anterior teeth 0.68

Table 1. Patient characteristics

	Total
Patients	$n = 98$
Sex	
Female	57
Age	46.6 ± 10.3
Smoking	
Current smokers	26
Former and never smokers	72
IL-1-polymorphism	
Negative	62
Positive	36
Initial diagnosis	
Moderate ChP	29
Severe ChP/AgP	69
Insurance status	
Private	33
Public	65
Education	
⩽9 years	5
>9 years	47
Higher college education	46
Teeth	
Teeth	$n = 2249$

ChP, chronic periodontitis; AgP, aggressive periodontitis; IL-1; interleukin-1.

Table 2. Mean number of visits over 10 years of supportive periodontal treatment (SPT)

	n	Visits
Total	98	14.83 ± 7.42
Gender		
Female	57	14.91 ± 7.81
Male	41	14.61 ± 7.09
SPT		
Regular	54	19.78 ± 3.88
Irregular	44	8.66 ± 6.16
Initial diagnosis		
Moderate ChP	29	13.24 ± 7.49
Severe ChP/ AgP	69	15.43 ± 7.44
Smoking		
Former and never smokers	72	14.64 ± 7.01
Smokers	26	15.19 ± 8.80
IL-1 polymorphism		
Negative	62	14.03 ± 7.38
Positive	36	16.08 ± 7.57
Education		
⩽9 years	5	17.20 ± 2.95
>9 years	47	13.29 ± 8.71
Higher college education	46	15.94 ± 6.29
Insurance		
Private	33	15.21 ± 6.59
public	65	14.57 ± 7.94
PCR		
<24% (median)	49	16.24 ± 7.00
⩾24%	49	13.33 ± 7.73

Table 3. Linear regression analysis: number of visits during supportive periodontal treatment (SPT) in relation to patient characteristics

	b	SE(*b*)	*T*	*p*
Constant	14.343	2.957	4.850	0.000
Plaque control record (>median)	− 0.201	0.067	− 2.997	0.004
Education	0.985	0.517	1.905	0.060
Interleukin-1 polymorphism	2.213	1.557	1.421	0.159
Diagnosis (severe ChP/AgP)	1.771	1.613	1.098	0.275
Gender	− 1.245	1.694	− 0.735	0.464
Insurance status	0.990	1.694	0.584	0.560
Smoking	0.879	1.557	0.524	0.602

Analysis of variance					
Model	Sum of squares	df	MSQ	*F*	*p*
Regression	862.491	7	123.213	2.429	0.025
Residual	4566.009	90	50.733		
Total	5428.500	97			

Dependent variable: number of visits during SPT; $n = 98$; $R^2 = 0.159$; R^2 adjusted = 0.093; standard error of estimate = 7.123.
df, degrees of freedom; MSQ, mean of squares; SE, standard error.

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Table 4. Mean number of subgingival scalings per tooth over 10 years of SPT including upper and lower percentiles (10%; 90%)

Patient characteristics	*n*	Scalings
Total	2249	1.17 (0; 4)
Gender		
Female	1328	1.17 (0; 4)
Male	921	1.17 (0; 4)
Initial diagnosis		
Moderate ChP	701	0.90 (0; 3)
Severe ChP/	1548	1.29 (0; 4)
AgP		
Smoking		
Former and never smokers	1639	1.06 (0; 4)
Smokers	610	1.46 (0; 4)
IL-A polymorphism		
Negative	1456	1.08 (0; 3)
Positive	793	1.33 (0; 5)
Education		
⩽9 years	94	1.97 (0; 5)
>9 years	1032	1.01 (0; 3)
Higher college education	1123	1.25 (0; 4)
Insurance		
Private	774	1.06 (0; 4)
Public	1475	1.23 (0; 4)
PCR (median)		
<24%	1117	1.07 (0; 3)
⩾24%	1132	1.27 (0; 4)

PCR, plaque control record.

Table 5. Mean number of subgingival scalings per tooth over 10 years of SPT including upper and lower percentiles (10%; 90%)

Tooth characteristics	*n*	Scalings
Total	2249	1.17 (0; 4)
Tooth type		
Anterior teeth	1064	0.68 (0; 2)
Premolar	640	1.01 (0; 3)
Molar	545	2.41 (0; 7)
Initial bone loss		
⩽20%	651	0.53 (0; 2)
21–40%	940	1.10 (0; 3)
41–60%	472	1.60 (0; 5)
61–80%	136	2.50 (0; 7)
>80%	50	3.20 (0; 6)
Abutment status		
No abutment	1951	1.12 (0; 4)
Fixed bridgework/ crown	231	1.45 (0; 5)
Removable prosthesis	67	1.58 (0; 4)
Furcation involvement		
No furcation present	1567	0.71 (0; 2)
No furcation involvement	293	1.98 (0; 6)
Furcation involvement	389	2.42 (0; 7)
Surgery		
No regenerative therapy	2156	1.10 (0; 4)
Regenerative therapy	93	2.73 (0; 8)
Prognosis		
Good	1758	0.89 (0; 3)
Fair	375	1.99 (0; 6)
Hopeless	116	2.75 (0; 7)

scalings. Teeth without abutment were re-instrumented 1.12 times, fixed bridgework or crowns resulted in 1.45 scalings, and teeth carrying removable prostheses 1.56 times (Table 5). Teeth without multiple roots or furcation involvement showed a tendency for less re-instrumentation, which proved to be of statistical significance ($p = 0.003$).

During the 10-year period of SPT costs per tooth ranged from €1.21 (2.3 ×) (for a patient who showed up for only one visit) to a maximum of €266.26 (2.3 ×) or €404.72 (3.5 ×) (Table 7). On patient level only regular maintenance caused statistically significant higher costs. IL-1-polymorphsim ($p = 0.075$) slightly failed statistical significance (Table 9). The higher number of re-instrumentations in patients with a higher PCR did not result in significantly higher costs for these patients ($p = 0.421$).

On a tooth level, costs (Table 8) proved correspondence to number of re-instrumentations and tooth type ($p < 0.001$), initial bone loss ($p < 0.001$), abutment status ($p < 0.001$), previous regenerative surgery ($p < 0.001$), and furcation involvement ($p = 0.002$), and location of the tooth in the maxilla ($p = 0.035$).

On average, for patients seen on a regular basis the costs per tooth per visit added up to €3.98 ± 0.89 (2.3 ×)/ 6.05 ± 1.35 (3.5 ×), whereas higher costs per visit and tooth incurred for individuals not showing up regularly added up to €5.01 ± 1.23 (2.3 ×)/ 7.62 ± 1.87 (3.5 ×).

Discussion

For this study, data of 98 patients, recruited consecutively 10 years ± 6 months after initiation of systematical periodontal treatment, were surveyed (Eickholz et al. 2008). It is generally accepted that SPT plays an important role in tooth preservation, but costs and effort put into supportive therapy are rarely considered (Davies et al. 2005). Brägger (2005) tried to test the hypothesis that periodontitis therapy is economically justified and found little data on economic assessment. In a recent review, the Sixth European Workshop on Periodontology addressed the cost-effectiveness of supportive periodontal care and used estimates for the costs based on patient charges from a specialist practice in England (Gaunt et al. 2008). To our knowledge there are no studies addressing the real costs of SPT.

In our study sample, patients attending SPT on a regular basis were in average seen twice per year (19.78 ± 3.88 visits in 10 years), which is consistent with the average recommendation of the PRA (Lang & Tonetti 2003).

Apart from recommendations, which supportive therapy was rendered to a specific tooth? Even a tooth with an initial bone loss of >80% (50 teeth in our study sample) only required an average of 3.2 (0; 6) re-instrumentations during the 10-year span of SPT. The mean number of scalings for the 390 teeth exhibiting furcation involvement was 2.42 (0; 7). Even hopeless teeth (Checchi et al. 2002) were only re-instrumented 2.75 (0; 7) times (Table 5). This poses a comparatively small effort for tooth retention over 10 years and costs were considerably lower than those for alternative procedures.

Actually cost of SPT may be calculated on a patient or tooth level. However, by calculating expenses per tooth in this analysis we have demonstrated that not only different types of patients (aggressive and generalized severe chronic/mild and moderate chronic periodontitis, IL-1 polymorphism) but also different types of teeth (single-/multi-rooted, abutment, different degrees of bone loss) cause different cost. Thus, the number of teeth per patient is not a sufficient variable to explain cost per patient. Furthermore, by calculating expenses per tooth for different tooth types we provide estimates to compare cost for SPT of a certain tooth with treatment that may be needed after extraction. SPT of a molar will be more expensive than SPT of an otherwise comparable anterior. For the decision on whether to maintain or replace a particular tooth we need an estimate of the costs for both alternatives. After extraction of one tooth the patient will only save the expenses for further maintenance of this tooth. Still, he will have to pay for all remaining teeth. To discuss cost/benefit issues of maintenance or extraction we focused on

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Table 6. Multilevel analysis: number of scalings during SPT in relation to patient and tooth characteristics

	Estimate	SE	*Z*	*p*
Constant	− 0.021	0.744	− 0.028	0.978
Patient level				
Regular SPT	0.676	0.207	3.270	0.001
Plaque control record (>median)	0.381	0.207	1.838	0.066
Smoking	0.260	0.242	1.073	0.283
Interleukin-1 polymorphism	0.236	0.212	1.110	0.267
Education	0.047	0.072	0.660	0.510
Diagnosis (severe ChP/AgP)	0.037	0.221	0.165	0.869
Male sex	0.031	0.233	0.134	0.893
Age	− 0.019	0.011	− 1.676	0.094
Insurance status	− 0.205	0.240	− 0.852	0.394
Tooth level				
GTR	0.953	0.195	4.890	<0.001
Tooth type (molar)	0.878	0.207	3.270	0.001
Initial bone loss	0.390	0.047	8.296	<0.001
Furcation involvement	0.304	0.102	2.977	0.003
Abutment status	0.202	0.094	3.109	0.002
Maxilla	0.184	0.077	2.370	0.018

Dependent variable: number of scalings during SPT; $n = 98$ patients, 2249 teeth.
SE, standard error; GTR, guided tissue regeneration.

Table 7. Mean costs in Euros per tooth over 10 years of supportive periodontal treatment (SPT)

Patient characteristics	*n*	Costs (€2.3-fold)	Costs (€3.5-fold)
Total	2249	60.52 ± 42.37	91.99 ± 64.40
Gender			
Female	1328	59.87 ± 42.58	91.00 ± 64.72
Male	921	61.48 ± 42.06	93.45 ± 63.93
Initial diagnosis			
Moderate chronic	701	52.18 ± 40.71	79.19 ± 61.88
Severe chronic/aggressive	1548	64.31 ± 42.58	97.75 ± 64.72
Smoking			
Former and never smokers	1639	58.99 ± 40.81	89.66 ± 62.03
Smokers	610	64.66 ± 46.08	98.28 ± 70.04
Interleukin-1 polymorphism			
Negative	1456	56.99 ± 41.17	86.62 ± 62.58
Positive	793	67.03 ± 43.77	101.89 ± 66.53
Education			
⩽9 years	94	85.32 ± 42.44	129.69 ± 64.51
>9 years	1032	54.28 ± 43.89	82.51 ± 66.71
Higher college education	1123	64.20 ± 39.70	97.58 ± 60.34
Insurance			
Private	774	60.20 ± 39.92	91.50 ± 60.68
Public	1475	60.70 ± 43.61	92.26 ± 66.29
PCR (median)			
<24%	1117	62.05 ± 39.58	94.32 ± 60.16
⩾24%	1132	59.03 ± 44.92	89.73 ± 68.28

the respective teeth in question not on cost per patient.

The strongest confounder for costs per patient during SPT was regularity of maintenance, which is plausible. However, patients not showing up on a regular basis incurred higher charges per session. They were seen only 8.66 ± 6.16 times during the 10-year study period. Although cost per appointment was higher than for regular attendees, their total costs were significantly lower. Over the 10-year period irregulars saved money regarding SPT. However, they paid more in different currency. Patients of the irregular SPT group lost significantly more teeth (about five times more) than regular SPT patients (Eickholz et al. 2008). It may be speculated that these tooth losses caused additional costs for replacement.

Interestingly, the insurance status did not have an impact on either frequency of SPT or costs per tooth. Because private insurance covers the dentist's fees and state insurance does not, one could assume that the higher costs for patients themselves would lead to a higher drop-out rate in people with compulsory insurance. This was not the case in our study sample.

What alternatives do we have to tooth retention via SPT? Depending on the location of the tooth, the gap could be left untreated. This may be an option in the molar region without causing aesthetical deficits. If the gap left by an extracted tooth is aesthetically or functionally intolerable, basically three treatment alternatives are available: (1) fixed partial denture (bridgework), (2) removable partial denture, or (3) dental implants.

The maximum spent over 10 years on a single tooth in our sample of 2249 teeth was €266.26 (2.3 ×) or €404.72 (3.5 ×) compared with a minimum of €790 for a removable prosthesis, €1650 for bridgework or €2050 for insertion of an implant. Apart from the insertion of a prosthetic alternative, each patient still needs to pay for maintaining both the remaining and the replaced teeth. Further, the prosthetic alternative might lead to additional costs in the course of the years due to technical complications (e.g. fractures of veneers, implant screw fractures). Accordingly the costs for replacement alternatives would be even higher. Additionally, use of neighbouring teeth as abutment for fixed or removable dentures will deteriorate the prognosis of the respective teeth (Pretzl et al. 2008).

This implies that maintenance of a tooth over 10 years is a lot cheaper than replacing it. Thus, we could show that SPT is the most cost–beneficial (Davies et al. 2005) alternative. But Brägger (2005) and Davies et al. (2005) recommended focusing not only on cost–benefit analyses weighing all costs against all consequences of an intervention in monetary units, but also to consider cost-effectiveness and cost utility. Effectiveness analyses are composed of balancing monetary units against non-monetary units, i.e. survival and reduction of tooth mortality. Utility analyses consist of monetary costs weighed against consequences represented in a respective utility unit, representing how much a tooth, dentition, and patient profit from a service rendered.

So there are technical, aesthetic, functional, and biological influences to be considered in order to draw conclusions. Berglundh et al. (2002) reviewed the literature on implant complications and

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Table 8. Mean costs in Euros per tooth over 10 years of supportive periodontal treatment (SPT)

Tooth characteristics	*n*	Costs (€2.3-fold)	Costs (€3.5-fold)
Total	2249	60.52 ± 42.37	91.99 ± 64.40
Tooth type			
Anterior teeth	1064	23.45 ± 34.17	35.64 ± 51.94
Premolar	640	58.23 ± 38.18	88.51 ± 58.03
Molar	545	77.07 ± 56.83	117.15 ± 86.38
Initial bone loss			
⩽20%	651	46.85 ± 31.67	71.21 ± 48.14
21–40%	940	59.54 ± 40.34	90.50 ± 61.32
41–60%	472	69.07 ± 44.54	104.99 ± 67.70
61–80%	136	88.47 ± 56.68	134.47 ± 86.15
>80%	50	100.47 ± 54.18	152.71 ± 82.35
Abutment status			
No abutment	1951	59.66 ± 41.86	90.68 ± 63.63
Fixed bridgework/crown	231	64.03 ± 46.71	97.33 ± 71.00
Removable prosthesis	67	73.70 ± 39.10	112.02 ± 59.43
Furcation involvement			
No furcation present	1567	54.30 ± 34.64	82.54 ± 52.65
No furcation involvement	293	72.77 ± 49.78	110.61 ± 75.67
Furcation involvement	389	76.40 ± 56.31	116.13 ± 85.59
Surgery			
No regenerative therapy	2156	59.40 ± 41.20	90.29 ± 62.62
Regenerative therapy	93	86.78 ± 58.08	131.91 ± 88.28
Prognosis			
Good	1758	55.10 ± 37.46	83.75 ± 56.94
Fair	375	75.71 ± 50.14	115.08 ± 76.21
Hopeless	116	93.73 ± 56.21	142.83 ± 85.44
Teeth			
Remaining	2147	60.85 ± 42.08	92.49 ± 63.96
Lost	152	59.06 ± 41.66	89.77 ± 63.32

Table 9. Multilevel analysis: Mean costs in Euros during SPT in relation to patient and tooth characteristics

	Estimate	SE	*Z*	*p*
Constant	8.970	19.245	0.466	0.641
Patient level				
Regular SPT	41.597	5.373	7.738	<0.001
Smoking	9.234	6.284	1.469	0.142
Diagnosis (severe ChP/AgP)	6.270	5.710	1.098	0.272
Plaque control record (>median)	4.340	5.389	0.805	0.421
Interleukin-1 polymorphism	9.803	5.503	1.781	0.075
Education	1.353	1.853	0.730	0.466
Male sex	0.990	6.018	0.165	0.869
Age	−0.108	0.286	−0.378	0.705
Insurance status	−7.136	6.219	−1.147	0.251
Tooth level				
GTR	13.667	2.812	4.860	<0.001
Tooth type (molar)	11.919	2.601	4.582	<0.001
Initial bone loss	5.775	0.686	8.413	<0.001
Abutment status	4.809	1.371	3.508	<0.001
Furcation involvement	4.488	1.463	3.067	0.002
Maxilla	2.341	1.113	2.104	0.035

Dependent variable: costs of SPT per tooth; $n = 98$ patients, 2249 teeth.
SE, standard error; GTR, guided tissue regeneration.

described a loss before loading in 2.5% of all inserted implants and another 2–3% loss during the first 5 years in function for fixed reconstructions (>5% in overdentures). Hence an implant loss of at least 5% can be assumed during the first 5 years. Lulic et al. (2007) presented a review on survival rates and complications of fixed dental prostheses and found a survival rate of 96.4% after 5 and 92.9% after 10 years. In our study sample 155 out of 2249 teeth were lost in 10 years, corresponding to an average loss of 7%. In patients seen on a regular basis only 2% of teeth were lost (Pretzl et al. 2008).

Regarding biological complications, sensory disturbances occur in 1–2% of all implants set (Berglundh et al. 2002) and can be excluded for natural teeth.

DeRouck et al. (2008) reported on patient's satisfaction with aesthetics in 93% of implants set in the pre-maxillary region after 1 year. In our study sample three of the patients regarded their dental aesthetics as fair and none as unsatisfactory; accordingly, 97% were content with the aesthetic outcome 10 years after initiation of periodontal therapy (Eickholz et al. 2008). Hence it can be concluded that tooth preservation via SPT is both a reasonably priced and technically, biologically, and aesthetically effective alternative compared with extraction of a periodontally impaired tooth and insertion of an implant.

It was suggested several times that financial aspects partly influence patient's compliance and thereby the outcome of periodontal therapy (Wilson 1996, Fardal 2006). An approach to enhance compliance with recommended therapy might be to stress the financial benefit of periodontal maintenance therapy compared with alternative procedures.

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Address:
Bernadette Pretzl
Sektion Parodontologie
Poliklinik für Zahnerhaltungskunde
Mund-, Zahn- Kieferklinik
Heidelberg
Im Neuenheimer Feld 400
69120 Heidelberg
Germany
E-mail: bernadette_pretzl@med.uni-heidelberg.de

Clinical Relevance

Scientific rationale for the study: Long-term retention of teeth in function is the ultimate goal of periodontal therapy. This study aims to assess costs for and effort of tooth preservation through supportive periodontal treatment.

Principal findings: SPT is a cost-beneficial treatment. Maintaining a periodontally compromised tooth over 10 years is less expensive than extraction and replacement of this respective tooth.

Practical implication: Periodontal maintenance care is a valid tool to prevent tooth loss and maintain a favourable periodontal status. Dentists need to discuss with their patients the medical benefit as well as the costs of SPT and the effort required.

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