



Tooth loss after periodontal treatment—Mining an insurance database

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ARTICLE INFO

Keywords:

Periodontics
Treatment outcome
Dental scaling
Re-intervention
Extraction

ABSTRACT

Objectives: The aim of this study was to evaluate tooth loss after periodontal treatment.

Methods: The data was collected from the digital database of a major German national health insurance company. Periodontal treatment was the intervention in the treatment group. Kaplan-Meier survival analyses on the patient level with the primary outcome extraction were carried out over four years. A control group without treatment was matched and analysed. Differences were tested with the Log-Rank-test. Extraction incidences were calculated over a matched observation period six years before and four years after treatment for both treatment and control group.

Results: A total of 415,718 periodontal treatments could be traced. Focussing on the outcome “extraction”, the cumulative four-year survival rate was 63.8% after periodontal treatment. The matched control group without periodontal treatment showed a survival rate of 72.5%. These differences were significant ($p < 0.0001$). The extraction incidence over time was higher in a four-year period after periodontal treatment compared to a six-year period before periodontal treatment.

Conclusions: The outcome of periodontal treatment was acceptable. In about two thirds of the patients, extractions could be completely avoided within a four year period after treatment.

Clinical significance statement: This study within the German national health insurance system shows that extractions were not observed after periodontal treatment in the majority of cases. Although periodontitis is a chronic disease, patients suffering from periodontitis have a considerable chance to prevent further tooth loss.

1. Introduction

Periodontitis is one of the most prevalent oral diseases worldwide. Numerous studies showed a high prevalence within adults in many developed countries [1–4]. The major consequence of periodontitis is an increased mobility of teeth followed by tooth loss. Therefore, the aim of periodontal treatment is to avoid tooth loss in the long-term perspective.

Several observational studies on periodontal treatment report low or moderate long-term extraction rates [5–7]. The negative influence of several risk factors, e.g. higher age, smoking or non-compliance with a recall program, have been described [7–9]. On a population level, it remains unclear to which extent periodontal treatment can avoid or reduce tooth loss. Based on insurance data, there is one study from Taiwan which monitored more than 150,000 patients after periodontal

treatment [10]. This study revealed extraction rates between 25% and 30% on a patient level. However, the observation period was only 1.5 years. Based on these disillusioning results, a high need for further research on the outcome of periodontal treatment under general practice conditions and on a population level was identified.

Aim of the present study was to evaluate to which extent periodontal treatment can avoid further tooth loss within a national health care system.

2. Materials and methods

This study based on routine data from a major German national health insurance company (BARMER, Berlin, Germany). In the context of an annual oral health care report, the study team had access to the company’s data warehouse. The study design was approved by the

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<https://doi.org/10.1016/j.jdent.2018.11.001>

Received 14 May 2018; Received in revised form 2 November 2018; Accepted 5 November 2018

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responsible local ethics board (EK 288072015).

This study was exclusively based on claims data. These routine data were not collected for scientific purposes. The basic unit of information within the database is a fee code. The fee code represents a provided medical service, for example a tooth extraction. Clinical findings or diagnoses are not available.

For basic treatment like extractions, fee codes and dates were accessible and allowed for tracing clinical courses on a day count basis. These data were available for a six-year period from January 1st 2010 to December 31st 2015. For periodontal treatment, the date the dentist charged the treatment fees was accessible. These periodontal data were available for a four-year period from January 1st 2012 to December 31st 2015. All data sets of patients that had been a member of the insurance company for the whole four-year observation period entered the analysis. Because of systematically missing data, some specific German regions had to be excluded.

The completed periodontal treatment as indicated by the date of charging the respective treatment fees was defined as the study intervention. Periodontal treatment within the German national health insurance system comprises: a primary clinical evaluation, conventional periodontal treatment by scaling and root planning, optional surgical interventions and up to four re-evaluation appointments. These parts of the periodontal treatment are completely paid by the insurance company. There is no patient fee. Only professional hygiene or cleaning as pre-treatment has to be paid privately by the patient. Based on the terms and conditions of the German national health insurance, there are certain tooth-related inclusion and exclusion criteria that enable periodontal treatment. These tooth-related inclusion criteria are pocket depths over 3.5 mm. Tooth related exclusion criteria are horizontal mobility more than 2 mm horizontally, vertical mobility, furcation involvement (code 3) or bone loss of more than 75%.

Kaplan-Meier survival analyses were conducted for the primary outcome extraction. Extractions within 60 days after charging of the periodontal treatment fees were not counted as primary outcomes because they were defined as connected to the periodontal treatment. A control group without periodontal treatment was matched with the treatment group. Matching was implemented as sampling with replacement. The control group was sampled from a pool of insurance members without periodontal treatment. Every person in the treatment group was labelled with gender, age-group (in five year blocks) and the federal state. For every combination of these factors, the proportion in the treatment group was calculated. The same was done for all potential control persons. The difference in proportions was used for a weighted sampling of the potential control group to match the treatment group. For example: 0.807% of the treatment group but only 0.762% of the potential control group are males in the age group from 35 to 40 years from the federal state of Bavaria. As a result, this group had to be oversampled by the factor of 1.059 (0.807/0.762) to match the treatment group. Differences between the groups were tested for significance using the Log-Rank Test. The level of significance was set to $P < 0.05$. Survival analyses were conducted on a day count basis. The observation period was between January 1st 2012 and December 31st 2015.

For a long-term description, an extended observation period was statistically created up to six years before and up to four years after treatment by pooling the available data. Again, all periodontal treatments carried out between January 1st 2012 and December 31st 2015 entered the analysis. The analysis was centered around the periodontal treatment. Extractions could be traced until December 31st 2015 that was four years at maximum for the early 2012 patients. Additionally, (only) extractions could be traced backwards to January 1st 2010 that was six years at the maximum for the latest 2015 patients. As a result, the possible range of view went from six years before treatment to four years after treatment. Thus, a time span of ten years relative to the treatment was analysable. In the middle of this time frame, observations were based on the full sample, declining to almost zero at both

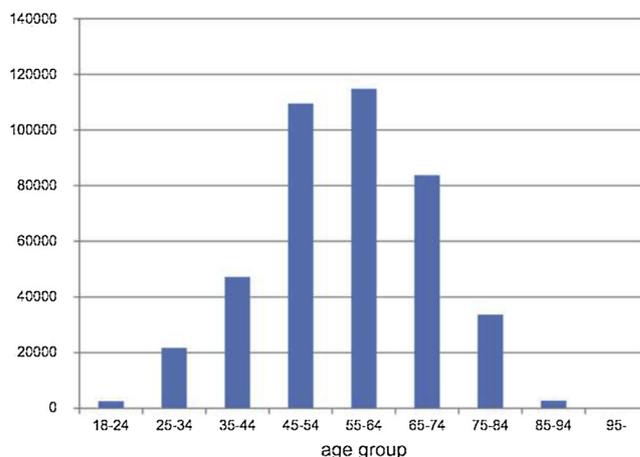


Fig. 1. Age Distribution in groups.

ends. For every single day on this time scale, the exact number of documented extractions and the exact number of people in our data set was known. Thus we were able to divide the extractions by the number of people to compensate for the varying sample size for different dates. Based on this approach, extraction incidences for treatment and control groups over ten years could be calculated and visualized. For visualization an AUC-diagram (area under curve) was chosen.

For a further ancillary analysis, the treatment group was divided into patients with at least one regular dental check-up a year and patients without. Extraction incidences were calculated for both groups for the observation period of ten years described above.

The software R (available from <http://www.r-project.org>) with the add-on package “survival” was used for statistical analyses.

3. Results

The treatment group comprised 415,718 patients with periodontal treatment. Within this group 263,376 (63%) were men and 152,342 (37%) were women. The age distribution is shown in Fig. 1. The control group was sampled from a pool of 5,697,745 insurance members without periodontal treatment. Roughly assumed, the periodontal treatments have been carried out by between 30,000 and 40,000 different dental practices per year.

3.1. Survival analyses

For tooth loss after periodontal treatment, the cumulative survival rate at four years was 63.8%. In contrast, the corresponding survival rate was 72.5% in the control group (Fig. 2). The difference was significant ($p < 0.0001$).

For different age groups, cumulative survival rates after periodontal treatment ranged between 52% and 81%. The highest four year survival rates were measured for the youngest patients while the lowest survival

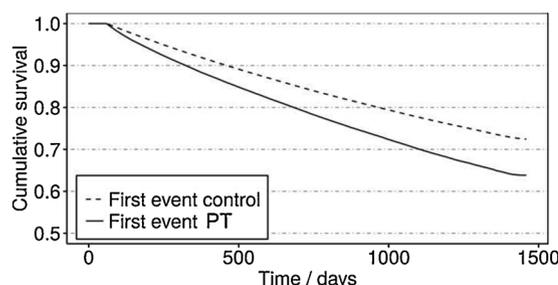


Fig. 2. Survival functions: First tooth loss after periodontal treatment (PT) compared to the matched control group.

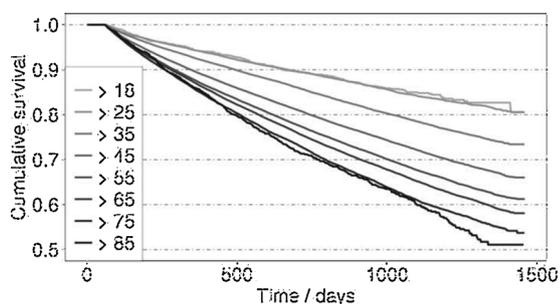


Fig. 3. Survival functions: First tooth loss after periodontal treatment in different age groups.

rates were measured for the oldest patients (Fig. 3). The survival rates in the age groups in between ranked exactly in descending order relative to age.

3.2. Extraction incidences over ten years

The development of the extraction incidences over time is shown in Fig. 4. Before periodontal treatment, the extraction incidences are similar in both treated and untreated patients. Within the untreated patients, the extraction incidence remains stable over the whole ten year period. In the treated patients, shortly before periodontal treatment the extraction incidence rises. This is represented by a peak before zero point on the time line in Fig. 4. The zero point itself marks the date when the dentist charged the periodontal treatment fees. After periodontal treatment, the incidence of extractions is decreasing and levelling out at a level higher than the initial. This extraction incidence remains stable over the following 3.5 years. The incidence level is approximately 1/3 higher than that before treatment (Fig. 4).

Fig. 5 shows the comparison between treated patients with and without regular annual dental check-ups. Before treatment, the extraction incidences are lower in patients without regular check-ups. However, the peak of extractions closer before and around periodontal treatment is much higher. After the peak, the incidence levels become similar (Fig. 5).

4. Discussion

Focussing on extraction after periodontal treatment, our study

revealed a cumulative survival rate of approximately 64% at four years based on an exceptional high number of cases. However, a number of limitations have to be taken into account to facilitate an appropriate discussion and to avoid over-interpretation.

4.1. Limitation

The major limitation of this study was the data source being only fee code based data provided by a national health insurance company. The database comprised the complete number of all conducted treatments for the 8.5 million members of this national health insurance company representing approximately 10% of the German population in December 2015. Unfortunately, there was no additional clinical information except for the documented treatment fee codes. The absence of clinical findings and clinical diagnoses lead to a limited interpretation corridor for the presented results. However, this limitation is unavoidable and similar to the ones discussed with other analyses on different dental treatment outcomes from this data source [11–15]. Given appropriate interpretation, the value of the respective results is unquestionable. The use of massive data resources for evaluating outcomes from general dental practice is gaining increasing importance within the scientific community.

Regarding this analysis of outcomes after periodontal treatment, an additional limitation occurs. The relevant treatment codes are only available on a patient level and cannot be assigned to specific teeth. Thus different to previous analyses, there was no possibility of tracing tooth careers. This limitation has significant implications for the discussion of the results. A single tooth periodontal treatment and its potential extraction cannot be directly linked. We do not know whether an extracted tooth had actually undergone periodontal treatment or not. However, periodontitis is more a site specific disease. As described by the terms and conditions of the German national health insurance system, it must be seen as a complex, patient related treatment approach and not as a single tooth intervention. Therefore, the more complex view on a patient level might be judged appropriate. Furthermore, tooth loss after periodontal treatment on a patient level is an accepted and relevant core outcome which is widely used in periodontal studies [16–23].

The control group was formed by patients without periodontal treatment. It is not known whether these patients suffered from periodontitis or not because diagnostic information was not available. This group is not a control group in the sense of a randomized controlled

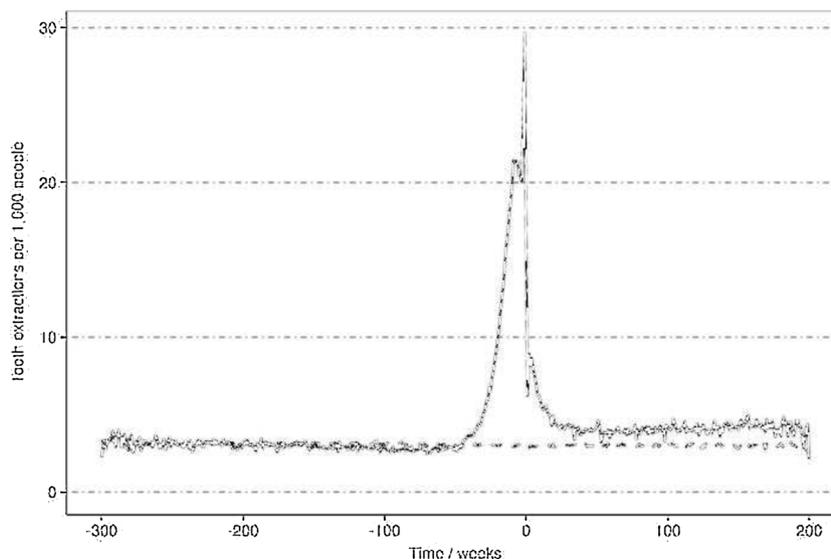


Fig. 4. Incidence of extractions for patients with periodontal treatment (continuous line) and without periodontal treatment (broken line) over time. The time point zero represents the event of the completed (charged) periodontal treatment.

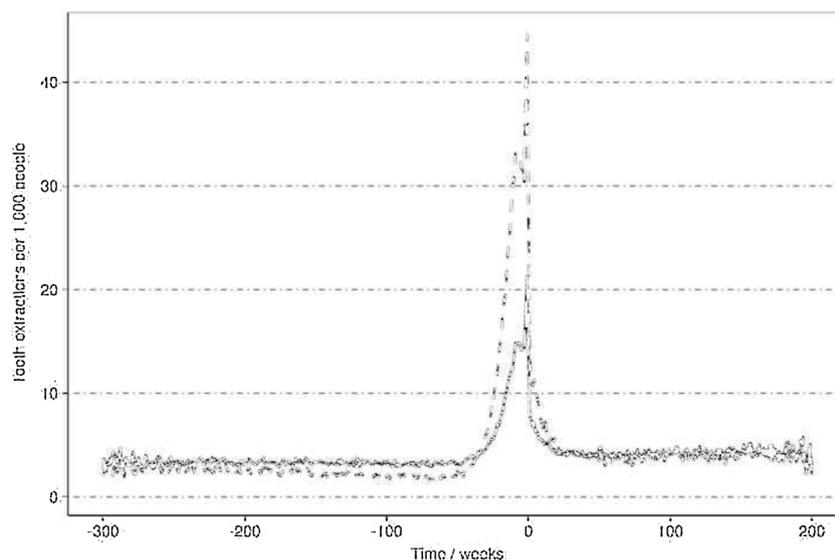


Fig. 5. Incidence of extractions for patients with periodontal treatment with (continuous line) and without regular dental check-ups (broken line).

trial but it gives information about the development of extractions and extraction incidences in an untreated population. Within this control group, periodontitis might not exist, not be diagnosed and not be treated for any reason.

Within our database, we do not see a consistent dentist identification number for data protection reasons. The dentist number changes every three months so that we cannot directly trace a dental practice. In a whole year, we see roughly 120,000 different dentist numbers in the data.

Fee code based data may be compromised by a mix-up of teeth and fee codes although the respective errors may to a certain extent compensate for one another. This aspect can be judged minor due to the patient centred evaluation strategy. The Kaplan-Meier survival analysis is accepted for outcomes after interventions in medical and dental studies. It is also accepted for the analysis of massive data [11,12,14,15,24–29]. From the clinical point of view there is unfortunately either no information on the specific diagnosis or on the degree of severity. There is also no possibility of linking treatment quality and treatment time within the respective database.

4.2. Interpretation

Interpreting the presented results is difficult due to the lack of comparable studies. The only study analysing big data for outcomes after periodontal treatment is based on data from Taiwan [10]. This study analysed 172,082 cases. Extractions were registered in 25–30% of the patients up to 1.5 years after periodontal treatment. Terms and conditions of the Taiwan health care system are different to the German system. In comparison, our results seem to be superior.

Focussing on outcome data from private practices, the comparison of the results becomes even more difficult. As in general medicine, there is a trend to form practice-based research networks also in dentistry. There is one network (PEARL) from the US which also focusses on periodontal treatment [30,31]. However, this network has not yet published any data on treatment outcomes. The majority of data gathered in private practice settings was collected in single private practices [5–7,32–34]. From these, the study by Stadler et al. is remarkable because the results are based on 733 cases which were retrospectively analysed up to 33 yrs [32]. Because the statistical approaches are dissimilar, a direct comparison is inappropriate. Roughly however, most results from private practices seem to be superior compared to ours [5,32]. Possibly, private practitioners involved in research might tend to have different treatment approaches compared

to the average general dentist.

Beside of the limited possibilities of judging our results in view of the literature, it remains difficult to interpret the outcomes themselves. Primarily, the aim of periodontal treatment is to stabilise the disease process and to prevent further progression. Secondly, success is often measured by the extent to which extractions can be avoided and teeth can be saved. Principally, teeth with a bad short-term prognosis should be extracted before periodontal treatment in order to reduce bacterial contamination during the treatment and to ensure a high probability of treatment success. On the other hand, also teeth with a hopeless prognosis can sometimes be saved for several years and patients might insist extracting those teeth. Of course, one third of patients with tooth loss after periodontal treatment within four years cannot be ignored, this even more as extractions within 60 days directly after periodontal treatment were not counted. However, the sustainability of periodontal treatment on a population level can still be rated acceptable. Even other long-term rates of tooth retention after periodontal treatment range widely between 45% and 88% on a patient level. Additionally, periodontal disease is multifactorial and the outcome is not only related to the periodontal treatment itself. Taking this into account, our results have to be judged even more positive. The causes for a compromised sustainability can only be speculated on. A successful periodontal treatment needs a strict post treatment management and supportive periodontal treatment [35]. However the question remains, whether such a strict management can be implemented within the terms and conditions of a (national) health care system on a population level. A second associated factor might be the patient's motivation and compliance. All in all, a considerable portion of patients appear to stay risk patients after periodontal treatment, at least over four years and possibly lifelong. Within a national health insurance system in which periodontal treatment itself is delivered free of charge for the patient, this compliance might be compromised.

Based on the wide spectrum of patients treated within this study and the limited volume of specific data, focussing our results on certain diagnoses or degrees of severity was not possible.

Our results revealed decreasing survival rates with increasing age. This is an expected result. Several other studies showed that increasing age is associated with a higher risk for tooth loss [5,8,18,22,33]. Overall, the results might indicate that periodontal treatment have been started too late in many. The regular use of dental check-ups was interpreted as a measure for the attendance pattern and the patient's attitude towards the utilisation of dental services for preventive reasons. As expected, the regular use of dental check-ups was associated

with lower tooth loss around the time of the periodontal treatment. Affected teeth might be earlier identified during a dental check-up and extracted before a future periodontal treatment. In a long-term perspective after periodontal treatment however, the extraction incidence was not significantly lower in the regular check-up group. A direct comparison to other studies is not possible because the regular use of dental check-ups has not been evaluated elsewhere. However, the compliance of patients after periodontal treatment has been evaluated in several studies [7,22,32]. Superficially, this compliance can also be interpreted as a positive attitude towards the prevention of oral diseases. The compliance after periodontal treatment was often associated with a lower risk for further tooth loss [7,22,32]. This association however was not detected for the regular use of dental check-ups in our data.

In the German national health insurance system, periodontal treatment itself does not require additional payment by the patient. Only professional hygiene and cleaning as a pre-treatment has to be paid privately by the patients for motivating reasons. Therefore, patients receiving these treatments can be expected to be at least basically motivated.

Concerning periodontal maintenance, Preshaw reported similar outcomes carried out by general dentists compared to specialists in a short term perspective [36]. An interesting question would have been whether the treatment observed has been provided by general practitioners or periodontal specialists. However, the database did not allow for this differentiation. Taking into account that there is a limited number of periodontal specialists available in Germany and that these specialists might prefer to charge privately, it can be assumed that the vast majority of the treatment observed in this study has been provided by general dentists.

4.3. Generalisation

The external validity of the presented results have to be rated carefully according to the context of interpretation. Focussing on the German population, the external validity can be judged quite high because the database comprises treatment for more than 10% of the German population. Focussing on other developed countries, the external validity might depend on the health care system. If periodontal treatment is paid or subsidized within a national health care system, the results can be expected in a comparable range. This hypothesis is supported by the results from Taiwan [10]. To other countries with a privately financed dental care system, the presented survival rates might not be directly transferable. We expect however, that the relation of survival rates between different groups is to some extent transferable also to those countries. This estimation of the external validity of the presented results is to some extent speculative.

5. Conclusions

The outcome of more than 400,000 periodontal treatments was acceptable. In about two thirds of the patients, extractions were completely avoided within a four year period after periodontal treatment.

Acknowledgements

The study was partially supported by the BARMER, a German national health insurance company. The first author is sometimes requested by the BARMER as a dental consultant on a freelance basis. All other authors declare no conflict of interests.

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