ACTA ODONTOLOGICA SCANDINAVICA, 2017
VOL. 75, NO. 7, 475–482
https://doi.org/10.1080/00016357.2017.1340668

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ORIGINAL ARTICLE

Long-term stability of splinted anterior mandibular teeth during supportive periodontal therapy

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ABSTRACT

Objective: The aim of the study was to retrospectively assess the survival rate and stability of periodontally compromised and mobile anterior mandibular teeth after splinting in patients under supportive periodontal therapy (SPT).

Materials and methods: Thirty-nine patients with splinted anterior mandibular teeth and SPT (≥1 visit/year) for 3–15 years were re-examined. Periodontal status, patient and tooth-related factors were assessed retrospectively before (baseline) and 3 years after splinting ($n = 39$ patients, 162 splinted teeth). For patients with splints inserted for more than 3 years, retrospective data after 5 ($n = 30$), 7 ($n = 24$), 10 ($n = 16$), 12 ($n = 8$) and 15 years ($n = 4$) was included, if available. At baseline, splinted teeth included at least one tooth with increased mobility combined with clinical attachment loss (CAL) ≥ 5 mm and ≥50% relative bone loss (RBL). Baseline RBL of splinted teeth was assessed for all patients. Change in RBL was assessed after 10 years, if available.

Results: No splinted tooth was lost within the first 3 years after splinting. One splinted tooth was lost 7 years after baseline and one 12 years after baseline. After 3 years mean(SD) periodontal probing depth of splinted teeth decreased from 3.39(1.41) mm to 2.12(0.37) mm and mean(SD) CAL from 5.61(1.66) mm to 5.09(1.67) mm and remained stable over the observation period. No change in RBL was observed over a 10-year period ($p = .213$). The survival rate of the splints until fracture or debonding was 74.4% after 3 years.

Conclusions: Periodontally compromised splinted teeth show a high survival-rate and periodontal stability during SPT.

ARTICLE HISTORY
Received 14 March 2017
Revised 26 May 2017
Accepted 4 June 2017

KEYWORDS
Fibre-reinforced-composite splint; long-term result of periodontal therapy; splinting

Introduction

The main objective of splinting anterior mandibular teeth is to reduce increased pathological tooth mobility. Mobility resulting from periodontal inflammation and/or traumatic occlusion may often be treated by an adequate anti-infective periodontal therapy and by the adjustment of occlusion. However, mobility caused by an apical shift of the rotational centre of the tooth and thereby a lengthened lever as it occurs in advanced alveolar bone loss, is not likely to be corrected. Particularly, in periodontal patients with severe horizontal bone loss and persisting tooth mobility after active periodontal treatment (APT) the patient's oral comfort concerning functional aspects including speaking, biting and chewing can be affected seriously and lead to oral discomfort. This applies in particular to periodontally compromised mobile incisors. Splinting of affected teeth is an option to improve the patients' comfort [1,2] and to provide better control of occlusion [1]. Furthermore, splinting often preserves patients from tooth extraction and complex and costly prosthodontics or implants. However, especially in cases of severe horizontal bone loss and high mobility, the decision whether to preserve or extract the affected teeth, is a challenging one. This decision should always be made on an individual level, taking into consideration the general factors of the patient and his expectations of the treatment.

Currently, there are many different methods and materials available to splint teeth temporarily or permanently [1]. For permanent splinting of incisors, external and internal fixed splints made from composite resin restorative materials with or without wire, mesh grids or glass fibre inserts are the most common solutions.

Despite the fact that increased mobility is frequently observed in anterior teeth of the lower jaw, there are only few studies investigating the survival rate of splinted teeth and the survival rate of the splints themselves in patients with severe periodontitis. The existing literature reports on decreasing periodontal probing depth (PPD) and clinical attachment loss (CAL) after active periodontal therapy and splinting of periodontally compromised and mobile mandibular teeth ranging from 6 months up to 4.5 years [3–5]. Concerning the survival rate of splints, studies show quite different results ranging from 94.8% in FRC-splints [4] after 4.5 years to up to 11 fractures of out of 19 splints within

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12 weeks [2]. Except for different types of composite that had no significant influence on survival rate of splints [4], the authors found no studies investigating further factors influencing the survival rate of splints and splinted teeth. Taken together, there is only little evidence on the long-term stability of periodontally compromised splinted anterior teeth.

The aim of the study was to retrospectively evaluate (1) the tooth loss rate and (2) the periodontal stability [CAL and relative bone loss (RBL)] of splinted mandibular incisors and canines and (3) the stability of the splints in patients with periodontitis attending regular SPT and having splints for 3 and up to 15 years. Furthermore, potential factors (baseline RBL, mobility, CAL, type of splint, existence of a composite adhered pontic within the splint) influencing tooth loss rate and the stability of the splints were tested for significance. Oral hygiene indices were compared before and after splinting to test the influence of splinting on dental home care efficiency.

Materials and methods

Patients that had an appointment for supportive periodontal therapy (SPT) between July 2014 and January 2016 in the Section of Periodontology (Department of Conservative Dentistry, Clinic for Oral, Dental and Maxillofacial Diseases, University Hospital Heidelberg, Heidelberg, Germany) were screened for splinted mandibular incisors and canines. If the patient fulfilled patient and tooth-related inclusion criteria and agreed to participate in the study by giving the written informed consent, re-examination was timed to be 3 years ±6 months after splint insertion. For patients with splints inserted for more than 3 years, the re-examination was timed to align with one of the defined observation time points during SPT: 5, 7, 10, 12, or 15 years (±6 months) after splint insertion. Patient-related inclusion criteria:

- Existence of severe chronic periodontitis (chP) or aggressive periodontitis (agP) [6] before periodontal treatment. Patients that were diagnosed according to another classification system were re-classified based on their baseline periodontal charts.
- APT and splint insertion at the Section of Periodontology of the Department of Conservative Dentistry, Clinic for Oral, Dental and Maxillofacial Diseases at the University Hospital Heidelberg at least 3 years ±6 months before recruitment.
- Regular attendance in the SPT program (no SPT interval interruption of more than 1 year) after APT.
- Informed written consent to participate in the study and permission for retrospective data analysis.

Tooth-related inclusion criteria:

- Existence of a composite or fibre-glass reinforced composite splint of 2–6 anterior mandibular teeth (including incisors and canines) that was inserted at least 3 years ±6 months ago during APT. APT was defined as the time period from the first oral hygiene training until successful completion of APT [no site with PPD ≥6 mm).
- The splint was directly made by using composite resin materials (Tetric, Tetric Evo Ceram, Tetric Evo Flow, Ivoclar Vivadent) with or without containing a fibre-glass core [pre-impregnated fibre-reinforced-composite resin (FRC), everStick Perio, Stick Tech] according to the standardized adhesion protocol of the Department of Conservative Dentistry Heidelberg (polishing and isolation of treated teeth, etching with 37% phosphoric acid for 30–60 s, application of OptiBond FL primer and adhesive, Kerr).
- Existence of at least one tooth with increased mobility according to Lindhe and Nyman (degree I: mobility in in labio-oral direction of 0.2–1 mm, degree II: mobility of 1–2 mm, degree III: exceeding 2 mm in labial-oral direction and or in vertical direction) [7] combined with a CAL ≥5 mm at least at one site of the affected tooth and ≥50% radiographic bone loss before splinting.
- Existence of an X-ray image of the affected teeth at the time of splint insertion ±18 months.
- No cross-bites in the front.
- No known oral parafunctions.
- The dental and periodontal status [PPD and CAL at six sites per tooth (mesiobuccal, centrobuccal, distobuccal, disto-oral, mesiocentral and mesiobuccal)] were fully assessed before splint insertion and APT and 3 years ±6 months after splint insertion. The first dental and periodontal status assessed before APT and splinting of teeth was defined as baseline.

The presented data are part of a study that was approved by the Institutional Review Board for Human Studies of the medical Faculty of Heidelberg University (Application # S-132/2014) and is registered at the German Clinical Trials Register (DRKS00011316).

ATP and SPT

APT included 3–4 appointments with assessment of oral hygiene indices (Plaque Control Record (PCR) [8] and Gingival-Bleeding-Index (GBI) [9]), motivation and instruction to optimize individual oral plaque control (instruction and demonstration for the correct tooth brushing technique and application of interdental brushes and/or dental floss), professional tooth-cleaning with hand instruments, polishing all teeth with rotating rubber cups and brushes using polishing paste, and application of fluoride gel. Afterwards, all patients received subgingival debridement under local anaesthesia (full-mouth disinfection [FMD] modified from Quirynen et al. [10]). Periodontal surgery was performed 3–6 months after FMD, if required. After successful completion of APT, patients participated in SPT at least once per year. Each SPT included assessment of oral hygiene indices (PCR and GBI), re-instruction and re-motivation to optimize individual oral plaque control, professional tooth-cleaning with hand instruments, polishing all teeth with rotating rubber cups and brushes using polishing paste, and application of fluoride gel. Dental and periodontal status (PPD and CAL at six sites per tooth)

were obtained at least once a year. Sites exhibiting PPD = 4 mm with bleeding on probing and sites ≥5 mm underwent subgingival re-instrumentation within the same appointment. The periodontal treatment protocol of the authors institution is standardized as described and was not changed since the year 2000.

Re-examination

Re-examination was timed to align with one of the defined observation time points during SPT: 3, 5, 7, 10, 12 or 15 years (±6 months) after splint insertion and contained a SPT-session and dental and periodontal examination (PPD and CAL at six sites per tooth). Furthermore, patients were asked about their smoking history (current, former and non-smokers according to Lang and Tonetti [11]) and their anamneses were updated accordingly. They were also asked about events of splint-fracture or debonding that were not repaired at the Department of Conservative Dentistry in Heidelberg.

Evaluation of patients' charts

The difference in number of splinted teeth and CAL of splinted teeth as primary outcome variables of this study was determined by comparing the dental and periodontal status at baseline (before splinting) and after 3 years of splinting. For patients that had their splints inserted for more than 3 years, the defined observation time points during SPT at 5, 7, 10, 12 and 15 years ±6 months after splint insertion were also compared, if available. Reasons for tooth loss were documented, if applicable. Tooth mobility before splint insertion was assessed from the baseline documentation (according to Lindhe and Nyman [7]). Retrospectively, the periodontal baseline diagnosis (chP or agP) was assigned to each patient and the SPT interval of each patient was checked. If a patient failed to adhere to the SPT interval (SPT interval more than 12 months), the patient was considered as non-compliant and excluded from the study. Furthermore, sex, age and smoking status were assessed. Data on the type of splinting material (only composite resin materials or composite resin material with inserted fibre-glass core) and existence of a composite adhered pontic within the splint (existing/not existing) was taken from the patients' medical chart. To retrospectively assess the survival rate of the splints, the whole medical chart of each patient was screened for a documented event of splint fracture or debonding. Fracture or debonding of the splint was defined as endpoint for splint survival. The time until splint fracture or debonding was counted in months and documented. The mean value for PCR and GBI of the whole dentition and of the splinted teeth only was calculated for the last appointment before splinting and the first appointment after splinting to compare the effectivity of oral hygiene before and after splinting. Number of endodontic treated splinted teeth before splinting and for the following observation period was evaluated as well as additional diagnosed caries lesions, restaurations or fillings. Occlusal posterior support of the right and left jaw (according to Eichner index [12]) and existence of antagonistic teeth in the upper jaw for the splinted teeth was documented.

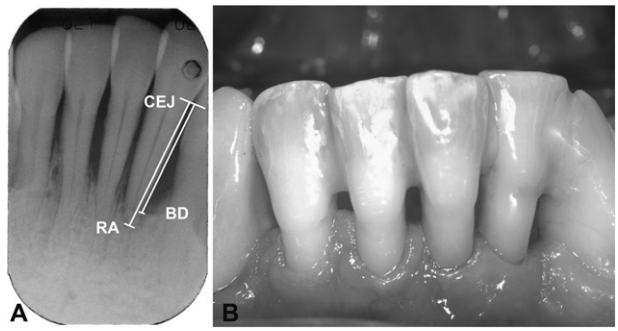

Figure 1. (A) Measurement of relative bone loss. CEJ: cemento-enamel junction; BD: radiographic bottom of the bony defect; RA: radiographic dental apex. (B) Clinical situation of the same patient after 15 years of supportive periodontal therapy.

Relative bone loss

RBL was assessed from the X-ray image at baseline (±18 months) by two calibrated examiners independently (M.R. and S.K.S.) at the most affected site of splinted teeth and calculated by dividing the distance (in mm) from the bottom of the bony defect to the cemento-enamel junction or the crown margin by the distance between the cemento-enamel junction or the crown margin to the radiographic apex of the root (Figure 1). Data analysis was performed by using the mean value calculated from the measurements of both examiners for one individual. If an X-ray was available, RBL at the same tooth was assessed for the patients that completed 10 years SPT after splint insertion.

Statistical analysis

All clinical data was entered into two data files independently by two different examiners (C.B. and S.K.S.). Both data files were compared and in case of different values, original findings were looked up and correct data were entered into the final data table. The patient was set as statistical unit. Descriptive statistics, generation of Kaplan–Meier estimator $\hat{S}(t)$ with 95% CI and Cox regression were performed by statisticians (D.S. and J.K.) (SAS® version 9.4, SAS Institute, Cary, NC). Statistics for oral hygiene parameters (GBI and PCR) and RBL were analysed by using a computer program (SPSS Version 22; SPSS Inc., Chicago, IL). The significance level was .05. Survival rate of splinted teeth and stability of splints was calculated applying the Kaplan–Meier estimator $\hat{S}(t)$ with 95% CI. Cox regression was used to determine the association between the stability of splints and the predictors baseline RBL, baseline CAL, baseline mobility degree, type of splint (only composite resin materials or composite resin material with inserted fibre-glass core), and existence of a composite adhered pontic within the splint (existing/not existing). Third molars and dental implants were excluded from analysis.

Results

Descriptive data of the study population

Forty-one patients attending SPT from July 2014 to January 2016 fulfilled inclusion criteria and agreed to participate (17 males, 24 females). These patients were re-examined by calibrated examiners and gave their written consent to participate in the study. Subsequently, two female patients were not included in the statistical analysis because of incomplete retrospective data. Finally, 39 patients (17 males, 22 females) with a mean age of 56.6 years (range 37–76 years) were included in the study. At baseline 32 patients were diagnosed with severe chP (82%) and 7 with localized or generalized agP (18%). Six patients were smokers (15.4%), 2 were former smokers (quitted smoking $\geq$5 years before splinting) (5.1%) and 31 were non-smokers (79.5%). In 27 individuals, splints were inserted before FMD (69.2%) and in 12 individuals (30.8%) splints were inserted between FMD and completion of APT. Four patients had splints that included 2 splinted teeth. In 10 patients, 3 teeth were splinted; in 11 patients, 4 teeth; in 4 patients, 5 teeth and in 10 patients, 6 teeth. Nine of the 39 splints contained a fibre-glass core (23.1%) and 30 were made from composite resin materials only (76.9%). At baseline, 6 patients had at least two adjacent teeth with a mobility degree I (15.4%), 24 patients had at least one tooth with a mobility degree II (61.5%) and 9 patients had at least one tooth with a mobility degree III (23.1%). At baseline and 3 years after splinting 162 splinted teeth were recorded. At the following observation time points 5, 7, 10, 12 and 15 years after baseline 125 ($n = 30$ patients), 98 ($n = 24$ patients), 71 ($n = 16$ patients), 30 ($n = 8$ patients) and 14 splinted teeth ($n = 4$ patients) were recorded, respectively. Mean(SD) relative radiographic bone loss of the most affected splinted anterior mandibular teeth at baseline was 72(14)% (range 50–100%; median 70%). At baseline, mean(SD) PPD of the overall dentition was 3.55 (1.25) mm (median 3.09 mm). Three years after splinting, mean PPD(SD) decreased to 2.33 (0.37) mm and remained stable over the following observation period. At baseline and 3 years after splinting 8 of the 162 splinted teeth showed endodontic treatment. During the following observation period, the root channel filling of one splinted tooth was revised twice. There was no requirement for additional endodontic treatment of any splinted teeth during observation period. After splinting, no additional caries lesions were diagnosed at the splinted teeth and no additional restaurations or fillings were required. During APT, three patients received periodontal surgery at splinted teeth (in all cases regenerative therapy). According to Eichner index [12], 33 patients showed left and right occlusal posterior support. Four patients showed posterior support only at one site of the jaw. Two patients showed no posterior support and no anterior antagonists. These two patients were wearing mucosa supported complete dentures in the upper jaw. The functional loading of splinted teeth by natural antagonists in the upper jaw was given in 37 patients. Descriptive data of the study population are shown in Table 1.

Table 1. Patient's characteristics.

	Baseline	3 years after splinting	5 years after splinting	7 years after splinting	10 years after splinting	12 years after splinting	15 years after splinting
Number of patients	39 (17 males)	39 (17 males)	30 (15 males)	24 (9 males)	16 (2 males)	8 (1 male)	4 (1 male)
Number of patients with chP (%)	32 (82.1%)	32 (82.1%)	23 (76.7%)	22 (91.2%)	14 (93.3%)	8 (100%)	4 (100%)
Mean(SD) number of teeth of the overall dentition	21.23(5.47)	19.97(5.79)	19.67(5.71)	18.42(5.60)	18.06(5.80)	17.63(5.22)	16.33(3.68)
Mean(SD) PPD of overall dentition	3.55(1.25)	2.33(0.37)	2.32(0.42)	2.33(0.48)	2.21(0.45)	2.28(0.30)	2.33(0.47)
Number of splinted teeth	162	162	125	98	71	30	14
Mean(SD) PPD of splinted teeth in mm	3.39(1.41)	2.12(0.37)	1.97(0.52)	2.25(1.04)	2.04(0.47)	2.18(0.69)	2.04(0.27)
Mean(SD) CAL of splinted teeth in mm	5.61(1.66)	5.09(1.67)	4.66(1.44)	5.03(1.42)	5.00(1.10)	4.70(0.58)	4.56(1.37)
Patients with composite adhered pontic	6	6	6	4	1	0	0

chP: chronic periodontitis; SD: standard deviation; PPD: periodontal probing depth; CAL: clinical attachment loss.

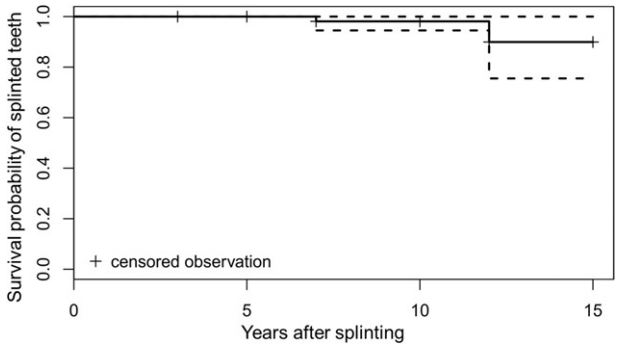

Figure 2. Kaplan–Meier estimator $\hat{S}(t)$ with 95% CI of tooth loss rate of the splinted anterior mandible teeth.

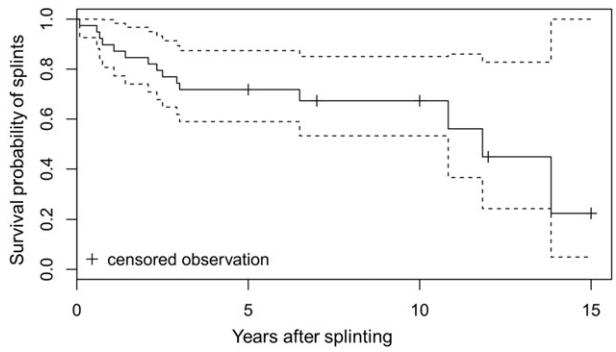

Figure 3. Kaplan–Meier estimator $\hat{S}(t)$ with 95% CI of splints until fracture or debonding (splinting stability).

Tooth loss rate of splinted teeth

No splinted tooth was lost within the first 3 years after splinting. One splinted tooth was lost 7 years after baseline and one 12 years after baseline. In both cases, the reason for tooth loss was an endodontic complication (root fracture and persistent apical inflammation after second revision of root channel filling). The affected patients showed full posterior and anterior occlusal support. Kaplan–Meier estimator of the survival rate of splinted anterior mandibular teeth is shown in Figure 2. Due to the small number of lost splinted teeth, no further statistical analysis was performed regarding influence of patient and tooth-related factors on tooth loss.

Periodontal stability of splinted teeth

At baseline, mean CAL(SD) of splinted teeth was 5.61(1.66) mm. Three years after splint insertion mean(SD) CAL decreased to 5.09(1.67) mm and did not change significantly over the following observation period (Table 1). The mean(SD) RBL at the most affected site of the splints was 72(14)% at baseline (range 50–100%; median 70%). For 11 patients, a 10-year X-ray was available. Ten years after splint insertion the mean(SD) RBL measured at the same sites was decreased to 63(17)% (range 42–95%; median 59%). An increase of RBL was detected only in three individuals (27.3% of observed cases). A refill of the bony defect was observed in six individuals (54.5% of observed cases) and in two individuals (18.2% of observed cases) the bone level remained stable (±1%) over 10 years. Statistical analysis revealed no statistically significant differences between RBL at baseline and after 10 years of splinting ($p = .213$, Wilcoxon-test).

Stability of the splints

Three years after baseline (at 36 months), survival rate of splints was 74.4% and 10 years after baseline, survival rate of splints was 67.3%. Kaplan–Meier estimator of the survival rate of splints until fracture or debonding is shown in Figure 3. In both patients without posterior and anterior occlusal support, a fracture of the splint was observed but in none of the patients with occlusal support in only one posterior half of the jaw. Cox regression revealed that baseline RBL, CAL, baseline mobility degree, type of splint and existence of a composite adhered pontic within the splint had no statistical influence on fracture/debonding probability ($p = .665$, $p = .682$, $p = .483$, $p = .751$, $p = .954$).

Oral hygiene parameters

Data of oral hygiene indices of 34 individuals before and after splinting were included in the statistical analysis. The oral hygiene data of five individuals had to be excluded from statistical analysis because of incomplete documentation. Mean GBI(SD) at splinted teeth was 12.8(23.5)% before splinting and 6.1(12.2)% after splinting. Mean PCR(SD) at splinted teeth was 35.9(31.3)% before splinting and 41.9(29.7)% after splinting. At the same appointments, mean GBI(SD) of the whole dentition was 9.5(14.0)% before and 5.1(6.8)% after splinting and PCR was 34.2(22.0)% before and 35.2(18.8)% after splinting. While there was a significant decrease in the mean GBI of the whole dentition and the splinted teeth before and after splinting ($p = .012$ and $p = .011$; Wilcoxon-test), there was no statistically significant change in mean PCR of the whole dentition and at the splinted teeth ($p = .561$ and $p = .374$; Wilcoxon-test).

Discussion

Tooth splinting has been discussed controversially for a long time. Despite the fact that increased mobility is frequently observed for anterior teeth of the lower jaw, there are only few studies investigating the survival rate of different splinting materials and splinted teeth in patients with periodontitis and no studies investigating factors influencing the survival rate of splints and splinted teeth. In our study, we re-evaluated dental and periodontal status of 39 patients and retrospectively analysed data of splinted teeth of at least 3 and up to 15 years. Most other studies evaluated data prospectively, but had a shorter observation period of 12 weeks [2] to up to 10 months [5] or, when observed for more than 3 years, with a smaller sample size [4].

In the presented study, no splinted tooth was lost within the first 3 years after splint insertion. This high survival rate reveals that splinting of periodontally compromised anterior mandibular teeth in combination with APT is an appropriate technique to maintain these teeth and to avoid tooth extraction. Particularly regarding patients with systemic diseases or medication that leads to contraindication of tooth extraction,

splinting is a therapeutic option that should be taken into consideration. One splinted tooth was lost after 7 years of splinting and another one after 12 years of splinting. In both cases the reason for extraction was an endodontic complication. After resection of the root from the crown and retrograde filling, the two lost teeth were re-inserted as composite adhered pontics. This procedure avoided tooth preparation for prosthodontic bridges or an implant surgery in periodontally compromised patients that show an increased risk for abutment tooth loss [13] and for developing peri-implantitis [14]. It should be mentioned that splinting or splinting in combination with a composite adhered pontic is often an adequate option, but not suitable for all dental situations. For example, the overall prosthetic planning of the patient should to be taken into consideration as it can be a contraindication for splinting, whereas a closed dental arch is likely suitable for splinting solutions. The authors found only one other study that also reported on the tooth loss rate of splinted teeth. This retrospective study included 19 patients and no splinted tooth was lost over a 4.5-year period [4], confirming the high survival rate of splinted teeth. Despite the lack of studies reporting about tooth loss rates of splinted teeth, there is evidence of tooth survival during long-term SPT in comparable cohorts. König et al. [15] retrospectively analysed the treatment outcomes of 142 compliant periodontal patients with at least 10 years of SPT. They found that increasing mobility worsened the prognosis of the tooth, but after 12 years the survival rate of teeth with mobility degree III was still over 90%. Baseline bone loss was identified to significantly contribute to tooth loss during long term SPT in patients with agP [16] and chP [17]. In the presented study, the authors were not able to statistical test baseline bone loss as a predictor for tooth loss in splinted anterior mandibular teeth because of the small number of lost teeth.

At baseline of the presented study, mean PPD(SD) of the splinted teeth was 3.39(1.41) mm and mean CAL(SD) was 5.61(1.66) mm. After 3 years, values decreased to 2.12 (0.37) mm and 5.09(1.67) mm, respectively, and did not change significantly over the following observation period. The decrease of 1.27 mm observed in mean PPD and CAL gain of 0.52 mm of the splinted teeth within the first 3 years can mainly be attributed to the success of APT and regular SPT, but an influence of splinting on these results can be discussed. While splinting of teeth without plaque-removal failed to prevent attachment loss in animals with experimental periodontitis [18], human studies showed higher CAL gain at splinted teeth than at non-splinted teeth in patients that were treated with regenerative periodontal therapy [19] and in patients that did not receive any active periodontal therapy [20]. The second parameter that the authors of the presented study retrospectively assessed to investigate periodontal stability in splinted teeth was the radiographic bone loss. In our study, a statistically significant change of RBL at splinted teeth over a 10-year period was not observed. In summary, the results for CAL and RBL over time show that under adequate SPT after APT the periodontal stability of splinted teeth with severe attachment loss can be maintained for a period of time. Comparable results were published by Kumbuloglu et al. [4]. They prospectively evaluated the performance of FRC splints on anterior mandibular teeth with at least one of these teeth exhibiting a mobility of grade III in 19 patients who completed periodontal therapy and underwent periodontal recall. The mean gain of 2.6 mm in CAL was higher compared to our study, but they did not report on bone loss of splinted teeth. In the same study, they found an overall splint survival rate of 94.8% after 4.5 years of observation. The survival rate was not significantly affected by the different composites they used. Regarding prospectively recorded survival rates of splints, Sekhar et al. [2] revealed a much higher failure rate. In their study, they included 20 individuals with splints (10 with stainless steel wire and composite splint; 10 Ribbond ribbon and composite splints) and observed 11 fractures within the study period of only 12 weeks. With a survival rate of 74.4% after 3 years regarding the splints, the results of our study fall in between the results of the studies discussed above. After 10 years of splinting, in 67.3% of all cases there was no requirement for repair. After 12 years, the splinting stability decreased under 50%. However, it should be mentioned that repairing of splints is easy, of low cost, and not time consuming. Furthermore, the authors also analysed whether baseline RBL, mobility degree, CAL, type of splinting and existence of a composite resin adhered pontic influenced the probability of splint fracture or debonding. However, our results failed to show any statistically significant influence of the analysed factors.

Compared to our and other published studies, Tokajuk et al. [5] investigated a larger group of patients with periodontitis. They included 56 patients with mobility degree II and III at any tooth. These teeth were fixed by fibre-core splints and observed for 10 months. As their study was not restricted to anterior mandibular teeth, it is difficult to compare their results with our study. The different tooth types show different occlusal loading and angulation. Because of this, the authors of the presented study included only mandibular incisors and canines. However, splinting of lower canines can be discussed as problematic in the view of canine guidance. While the publication of Tokajuk et al. [5] contains no information about tooth loss and splinting fractures, they point out that 'splinting gives back the function of mobile teeth' and that 'repair and hygiene care is very easy'. In contrast to this, Sekhar et al. [2] did a subjective splint evaluation and compared plaque scores to a control group. They found a higher degree of plaque control in the non-splinted teeth compared to splinted teeth, but the difference was not statistically significant. No differences in plaque-scores were identified compared to the control group. In a case series published by Agrawal and Chitko [21] none of the three patients that were observed for 1 year reported oral discomfort because of the splinting of anterior mandibular teeth. Regarding oral comfort, all patients reported an improvement of masticatory function after placement of splints. Because of retrospective data analysis, the authors did not include subjective evaluation of oral comfort before and after splinting, but analysed plaque and gingival bleeding indices before and after splinting. While there was a statistically significant decrease in GBI [9] at splinted teeth, there was no statistical

difference observed for the PCR [8]. Our results indicate that there is no difference concerning the patients' ability of dental plaque control before and after splinting. However, it has to be taken into consideration that both oral hygiene indices used (GBI [9] and PCR [8]) are dichotomous and do not grade the amount of dental plaque or gingival inflammation. Even though there is some evidence that splinting of anterior mandibular teeth before subgingival debridement by scaling and root planning (and thereby eliminating potential scaling-induced trauma) does not have any adjunctive effect on clinical outcomes when compared to splinting after subgingival debridement [3], it has to be mentioned that some splints in our study were placed before FMD and some after FMD. This may also have an impact on the results for oral hygiene indices, especially the GBI [9].

To our knowledge, the presented study is the first that tries to identify influencing factors on tooth survival rate and splinting stability in periodontally compromised anterior mandibular teeth. Although there are some publications regarding periodontal stability by using the CAL of splinted anterior mandibular teeth, none, except our study, observed the bone level of splinted teeth over a long-term period.

The loading of splinted teeth may also affect tooth loss rate of splinted teeth and stability of the splints. For that reason, the authors excluded patients with cross-bites in the front and known parafunctions. However, functional loading by antagonistic upper teeth and occlusal posterior support may also be an influencing factor. In our study, both patients with tooth loss showed full posterior and anterior occlusal support by natural teeth. According to this result, an influence of functional loading on tooth loss could not be demonstrated. However, in both patients that were wearing a mucosa supported complete denture in the upper jaw, a fracture of the splint was observed. Despite the small number of patients, this may indicate that splinting stability can be affected by antagonistic loading and that patients without posterior and anterior antagonistic support of natural teeth may be more susceptible for splint fractures.

The weaknesses of the presented study are that most of the data is retrospective and the number of participants is limited. The retrospective periodontal and dental parameters were measured by many different examiners and analysed X-rays were not standardized. To better interpret the results a gender matched control group with the same severity of periodontitis and mobility degree in the lower anterior teeth would be useful. However, according to the treatment concept of the authors institution, to splint (or if not possible to remove) teeth with highly increased pathological mobility and severe bone loss, it was not possible to recruit a control group. Another weakness the study is that only patients compliant with SPT were included. It would be also interesting to compare splinted tooth survival rate and splinting stability with non-compliant patients. Furthermore, it must be mentioned that all included patients were treated by periodontal specialist.

To identify tooth-related factors that enable the dentist to preserve a periodontally compromised anterior mandibular tooth for long-term by splinting more precisely, prospective studies with a larger number of patients are needed. Further investigations should also include oral comfort and masticatory function as well as the cost-effectiveness of such a procedure.

Conclusions

During the first 3 years after APT and splinting of periodontally compromised and mobile anterior mandibular teeth no tooth was lost. The periodontal stability, expressed by changes in CAL and RBL over time, was given over the whole retrospective observation period of 3 up to 15 years. The survival rate of the splints until fracture or debonding was 74.4% after 3 years. For all included factors, no statistically significant impact on splint stability could be demonstrated. No significant change in PCR before and after splint insertion was detected. Thus, this study indicates that splinting as adjunctive therapy to APT may be an adequate option to maintain severely periodontally compromised mobile anterior mandibular teeth in patients attending regular SPT.

Acknowledgements

The authors thank Rebecca Kohnen, Sonja Rahim and Suzan Karamustafa for helping with the recruitment of patients.

Disclosure statement

The authors report no conflict of interest. The study was self-funded by the authors and their institutions.

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