Clinical Oral Investigations (2019) 23:1435–1442
https://doi.org/10.1007/s00784-018-2565-0

ORIGINAL ARTICLE

Longevity of composite build-ups without posts—10-year results of a practice-based study

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Received: 23 April 2018 / Accepted: 9 July 2018 / Published online: 25 July 2018

Abstract

Aim The aim of this prospective, non-interventional, multi-center, practice-based study was, firstly, to evaluate the longevity of composite build-ups in endodontically treated teeth (ETT) without post placement and, secondly, to analyze factors influencing the success of these composite build-ups.

Methodology Each of seven general dental practitioners placed up to 50 composite build-ups without additional posts in ETT. Teeth were restricted to incisors, canines, and premolars. Several clinical data were recorded for 192 coronal restorations on ETT in 192 patients. Cox proportional hazard models were applied to analyze associations between clinical factors and time until failure.

Results Within a follow-up period of 10 years, 167 restorations were judged as successful [mean success time, 110 (105–115) months] and 180 teeth survived [mean survival time, 114 (110–119) months]. The main failure type was fracture of the restoration ($n = 15$). The annual failure rate was 2.4%. In bivariate Cox regression, both factors such as number of restored tooth surfaces and adhesive were significantly associated with the failure rate. In multivariate Cox proportional hazards regression, none of the investigated factors were significantly associated with the failure rate.

Conclusion For composite build-ups in ETT without post placement, high success rates could be found after up to 10 years of observation time. Within the limitations of the present study, none of the analyzed factors such as "tooth type" or "number of restored tooth surfaces" was a significant predictor for the failure rate.

Clinical relevance Endodontically treated teeth can be successfully directly restored with composite build-ups even when no additional post is inserted.

Trial registration The study was registered in the German Clinical Trials Register (DRKS-ID: DRKS00012882).

Keywords Clinical studies/trials · Clinical outcomes · Composite materials · Endodontics · Restorative dentistry · Risk factors

Introduction

In recent years, several studies analyzed the effect of post placement on the failure rate of post-endodontic restorations. Tooth type [1], positions [2], its function in the dental arch [3], and the degree of coronal substance loss [4, 5] seem to directly influence the longevity of post-endodontic restorations. Furthermore, the material of the post [6], the preparation design, i.e., ferrule effect [7], and the final coronal restoration [8] might affect the long-term success of posts in endodontically treated teeth (ETT).

Regarding failure rates of post-endodontic restorations without post placement, only a few in vitro [9–13] and clinical (University) studies [4, 14, 15] have analyzed the influence of various factors on the longevity of the restoration or compared no post with post placement. In some of the in vitro studies, the placement of posts did not reveal a significant effect on the fracture load [9–11, 13], whereas (other) in vitro studies showed an effect vice versa [10–12]. Contradictory results

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might be explained by the preparation design (ferrule vs. no ferrule), the inclusion criteria (only premolars vs. all teeth), and the different post materials (glass-fiber vs. metallic posts). Nonetheless, more catastrophic failures were observed with post compared with no post placement [10–12].

Contrastingly, in clinical studies with up to 3 years of follow-up, a positive effect on the survival rate by placing posts was reported. In two studies, this positive effect could be observed irrespectively of the remaining coronal walls [4, 15], whereas in another study, a positive effect could only be observed in the no-wall group [14]. Furthermore, in all three studies, catastrophic failures could only be observed in the no post groups (but not in the post groups). However, the preparation for a post might weaken the root [16]. The risk of perforation is also increased [16] resulting in (more) catastropic failures. Since significant influences of risk factors on failure of, e.g., dental materials appear only after longer observation times of up to 10 years [17], an observational period of at least 5 years has been recommended for indirect restorations [18].

Since no practice-based studies are available and in general, clinical long-term data are scarce, the aim of the present prospective, non-interventional, multi-center, practice-based study were, firstly, to evaluate the survival of teeth and success of restorations for ETT with composite build-ups only, and, secondly, to analyze the effect of various factors on restorative failures after up to 10 years of follow-up.

Materials and methods

This study is reported according to the STROBE guideline for cohort studies [19]. The study has been registered in the German Clinical Trials Register (DRKS-ID: DRKS00012882). According to the ethical committee of the Medical Chamber of the State Lower Saxony, no local review board approval is needed.

Study design

This study was a prospective, non-interventional, multi-center, clinical study.

Patient selection

Seven general practices were recruited from a German dental practice-based research network (Arbeitskreis Zahnärztliche Therapie). Patients with a need of restoration of at least one ETT were invited and screened between August 2006 and August 2009. Inclusion criteria were as follows:

1. need of root canal treatment and build-up restoration
2. symptom-free tooth with adequate root canal filling
3. incisors, canines, and premolars
4. one tooth per patient. In cases when more than one ETT was in need of treatment, the first one was included in the study
5. maximum of 50 patients/teeth per practice/dentist

There were no exclusion criteria with respect to (1) the amount of hard tissue loss and (2) the materials being used, except of composite for the build-up. The quality guidelines of the European Society of Endodontology [20] were used to evaluate the preservation of teeth.

Data extraction

Between August 2006 and February 2016, the following data were collected anonymously (without reference to patient names) in the eCRF (electronic case report forms):

- dates of a possible re-intervention (including information such as extraction of the tooth, renewal of build-up restoration, etc.)
- dates of root canal treatment and build-up composite restoration
- missing and filled teeth (MF-T) at the date of build-up restoration
- number of proximal contacts
- number of teeth in the respective jaw
- patient age and gender
- presence of a root canal "retention" of the build-up restoration
- private practice/dentist
- restored tooth surfaces
- size of the defect of the tooth before build-up restoration
- tooth type
- type of build-up restoration (material, adhesive)
- type of final restoration (fixed vs. combined fixed restoration)

The following data were not collected:

- general diseases of the patient
- number of remaining cavity walls
- presence or absence of a circumferential dentin collar of at least 1.5–2 mm in height (ferrule design)

Failure of treatment decision

The build-ups were assessed by clinical and intraoral radiographic examination. The interval for the radiographic examination was defined on an individual basis. Assessment was done by the dentist who placed the post when patients attended for routine care or recall. No intra- or inter-examiner calibration data were obtained during the study. The observation period started with the date when the post was inserted.

Success The build-up restoration was considered successful, if the restoration remained in situ, without clinical or radiographic signs of technical failures, loss of retention, root fracture, or caries around the restoration. Whenever the final restoration was renewed, recemented, or the tooth was extracted, the intervention was considered as failed (primary endpoint).

Survival The build-up restoration was considered as a "survival" if the restoration was still in function at the last check-up visit without clinical or radiographic signs of technical failures, loss of retention, or root fracture. If tooth extraction could be avoided (e.g., by "recementing" or renewal of the build-up), the observation period was not considered as censored or failed. Whenever the tooth was extracted, the intervention was considered as failed (secondary endpoint).

Statistical analyses

Statistical analyses have been described previously [21, 22]. In brief, descriptive statistics were tabulated (Table 1) and SPSS (SPSS 25.0; SPSS, Munich, Germany) was used for the Kaplan-Meier statistic, calculation of the annual failure rate, and crude associations between baseline characteristics and time until failure.

Results

In this study, 192 patients with a mean (SD) age of 46 (14) years and with 192 coronal restorations in endodontically treated teeth were included (Table 1). In the observation period, each dentist placed between 10 and 47 coronal restorations. All restorations demonstrated at least one proximal contact.

Kaplan-Meier survival graphs and log-rank test

Within a mean success time (95% CI) of 110 (105–115), months restorations in 167 teeth were considered as successful because no (further) intervention was needed (cumulative success rate, 87%) (Table 1). Furthermore, 180 teeth survived (cumulative survival rate, 94%). The annual failure rate calculated on the basis of "success" and "survival" was 2.4 and 1.6%, respectively. The main failure types were fracture of the build-up ($n = 15$)—resulting in two extractions and 13 recemented/renewed build-ups—and longitudinal fracture of the tooth ($n = 3$). Additionally, teeth were extracted due to periodontal reasons ($n = 3$), due to endodontic failures ($n = 3$), and without any given explanation ($n = 1$).

Cox regression analysis

Crude bivariate associations between the different baseline characteristics and failure rate are given in Table 1. One dentist, the grade of coronal destruction, the grade of coronal destruction/number of restored tooth surfaces, and the adhesive were significantly associated with an increased failure rate ($p < 0.25$). The results of the multivariate model (Table 2) revealed no significant associations between the investigated factors and the failure rate ($p > 0.05$).

Discussion

This prospective analysis of the success and survival of restorations placed in ETT without posts in seven private practices found overall low annual failure rates and high survival rates. None of the analyzed factors was a significant predictor for the failure rate.

This study in private practice environments showed a high longevity for ETT being restored with composite build-ups without additional post and direct composites or varying dentures (i.e., mainly crowns and bridges). Although, to date, no comparable long-term data for composite build-ups in ETT without post placement are available, previous studies on ETT with post placement showed higher AFR (4.6% [1] compared with 2.4%) and slightly higher cumulative failure rates (8% after 7 years [23] compared with 6% after 10 years). In the first university-based study, 55 out of 149 posts failed within 10 years and in the second study, 7 out of 87 posts did not survive. However, the authors of the first study highlighted the remarkably high failure rate in their study, which was explained by missing ferrule preparation in a large proportion of the included teeth.

Regarding the cumulative failure rate, the present study seems to show a very low failure rate (13% after 10 years) when compared to recent shorter studies analyzing build-ups in ETT without post placement. In studies in university settings, failure rates differed between 10% after 2.6 years [14], 30% after 2 years [15], and 38% after 3 years [4]. The wide range in failure rates might be explained by differences in the study location (university- vs. practice-based), the primary aim of the study (analysis of post placement vs. analysis of no post placement), the inclusion criteria (only premolars vs. all teeth vs. all teeth except molars), the final restoration (solely crowns vs. all types of restoration), and the number of included teeth without post placement (60–192). However, a wide range has also been reported for teeth with fiber-reinforced posts (from 1.5% after 5.3 years [24] to 37% after 10 years [1]). Thus, the present study shows a relatively low annual failure rate compared with available data in this field.

In the present study, the amount of dentin left was classified according to the "relation to the gingiva" ("build-up without contact to the gingiva," "build-up with contact to the gingiva," and "build-up subgingival") and also with respect to the "number of restored tooth surfaces" ("1–2 surfaces," "3 surfaces," and "≥ 4 surfaces"). The first classification was

Table 1 Frequency and number of failures of teeth included in study for the respective tooth surfaces as well as bivariate Cox proportional hazard regression analyses of time until failure by categories of each baseline characteristic

Category	Frequency [*n* (%)]	Failures [*n* (%)]	*p* value	HR	95% CI	Mean success time [months]	95% CI	AFR (%)
Dentist								
1	31 (16%)	3 (10%)		1.0	Reference	106.0	94.6–117.4	1.8
2	21 (11%)	10 (48%)	*0.014*	5.1	1.4–18.6	75.3	60.2–90.3	9.1
3	25 (13%)	3 (12%)	0.894	1.1	0.2–5.6	110.5	98.2–122.7	2.1
4	46 (24%)	4 (9%)	0.642	0.7	0.2–3.2	114.9	106.1–123.7	1.4
5	12 (6%)	1 (8%)	0.693	0.6	0.1–6.1	108.4	105.4–111.4	1.1
6	10 (5%)	1 (10%)	0.995	1.0	0.1–9.6	108.6	86–131.1	1.9
7	47 (24%)	3 (6%)	0.964	1.0	0.2–4.8	108.5	99.2–117.7	1.7
Overall	192 (100%)	25 (13%)				109.7	104.5–115	2.4
Tooth type								
Incisor	30 (16%)	4 (13%)		1.0	Reference	99.4	88.2–110.5	
Canine	23 (12%)	2 (9%)	0.692	0.7	0.1–3.9	111.4	101.1–121.7	
Premolar	139 (72%)	19 (14%)	0.938	1.0	0.4–3.1	109.3	103.2–115.5	
Overall	192 (100%)	25 (13%)						
Age								
< 30	32 (17%)	3 (9%)		1.0	Reference	109.3	96.6–122	
30–60	125 (65%)	16 (13%)	0.907	1.1	0.3–3.7	109.6	103.1–116.1	
> 60	35 (18%)	6 (17%)	0.864	1.1	0.3–4.5	107.5	96.7–118.3	
Overall	192 (100%)	25 (13%)						
Gender								
F	129 (67%)	19 (10%)		1.0	Reference	108.1	101.5–114.6	
M	63 (33%)	6 (3%)	0.321	0.6	0.3–1.6	111.5	103.2–119.7	
Overall	192 (100%)	25 (13%)						
MF-T								
> 20	97 (51%)	13 (13%)		1.0	Reference	111.1	104.6–117.6	
11–20	84 (44%)	11 (13%)	0.756	1.1	0.5–2.5	106.5	98.1–115	
≤ 10	11 (6%)	1 (9%)	0.947	1.1	0.1–8.2	109.3	95.5–123.2	
Overall	192 (100%)	25 (13%)						
Proximal contacts								
1	35 (18%)	2 (6%)		1.0	Reference	113.5	104.8–122.2	
2	157 (82%)	23 (15%)	*0.157*	2.8	0.7–12	108.0	102–114	
Overall	192 (100%)	25 (13%)						
Root canal “retention” of the build-up restoration								
No	129 (67%)	19 (15%)		1.0	Reference	108.1	101.5–114.6	
Yes	63 (33%)	6 (10%)	0.321	0.6	0.3–1.6	111.5	103.2–119.7	
Overall	192 (100%)	25 (13%)						
Grade of coronal destruction								
Build-up without contact to the gingiva	61 (32%)	9 (15%)		1.0	Reference	102.9	93.3–112.6	
Build-up with contact to gingiva	75 (39%)	5 (7%)	*0.118*	0.4	0.1–1.2	117.3	111.5–123.2	
Build-up subginvial	56 (29%)	11 (20%)	0.582	1.3	0.5–3.1	101.3	90.6–112.1	
Overall	192 (100%)	25 (13%)						
Number of restored tooth surfaces								
1–2 surfaces	33 (17%)	7 (21%)		1.0	Reference	92.0	79.3–104.6	
3 surfaces	85 (44%)	10 (12%)	*0.097*	0.4	0.2–1.2	113.0	106.5–119.4	
≥ 4 surfaces	74 (39%)	8 (11%)	*0.208*	0.5	0.2–1.4	108.5	99.8–117.3	
Overall	192 (100%)	25 (13%)						
Filling material								

Table 1 (continued)

Category	Frequency [*n* (%)]	Failures [*n* (%)]	*p* value	HR	95% CI	Mean success time [months]	95% CI	AFR (%)
Nanohybrid	42 (22%)	7 (17%)		1.0	Reference	107.4	96–118.8	
Microhybrid	139 (72%)	17 (12%)	0.803	0.9	0.4–2.2	108.1	101.9–114.2	
Other composites	11 (6%)	1 (9%)	0.508	0.5	0.1–4	117.0	109.8–124.2	
Overall	192 (100%)	25 (13%)						
Adhesive								
Two-step etch and rinse adhesive	142 (74%)	12 (8%)		1.0	Reference	114.4	109.2–119.6	
Other adhesive	50 (26%)	13 (26%)	*0.008*	2.9	1.3–6.4	97.8	86.4–109.2	
Overall	192 (100%)	25 (13%)						
Final restoration								
Composite build-up + direct composite	109 (57%)	13 (12%)		1.0	Reference	110.1	103–117.2	
Composite build-up + crown	50 (26%)	7 (14%)	0.959	1.0	0.4–2.5	108.6	99.4–117.7	
Composite build-up + bridge anchor	20 (10%)	2 (10%)	0.444	0.6	0.1–2.5	113.2	104.1–122.4	
Composite build-up + partial crown	8 (4%)	2 (25%)	0.547	1.6	0.4–7	92.5	65.3–119.6	
Composite build-up + telescopic crown	5 (3%)	1 (20%)	0.591	1.7	0.2–13.4	83.0	47.4–118.6	
Overall	192 (100%)	25 (13%)				109.7	104.5–115	

AFR annual failure rate, *MF-T* missing and filled teeth

Factors associated with time until failure ($p < 0.25$; italics) in the separate models were entered in the multivariate Cox regression model (Table 2)

used because of its simplicity and the second classification because of its dependence to the German Scale of Fees for Dentists. In both classifications, the decisions could be documented quickly without interrupting the daily routine of a private practice. However, both classifications are in contrast to those used in previous studies [1, 15, 25]. Here, the remaining cavity walls described the amount of dentin left. Due the early onset of the present study—the previous studies were published after the beginning of the present study—we did not use the same classification. Unfortunately, we could not (retrospectively) match our classification with the "newer" classification. Nonetheless, the results of the present study are in agreement with the results of the 10-year observational study on glass-fiber-supported postendodontic restorations [1]. As in our study, no significant association between numbers of remaining cavity walls and time until failure could be observed. Even when molars were excluded from risk analysis, no significant association could be found (re-analysis not presented). Contrastingly, in other studies, the number of remaining cavity walls was a significant predictor for the time until failure [15, 25, 26]. The somehow contrary results could be attributed to the different post-endodontic treatments (post vs. no post placement) or study durations (short-term vs. long-term studies). Another reason could also be that the slightly different definition of the classification systems (remaining cavity walls vs. relation to gingiva/number of restored tooth surfaces) may result in different levels of association between the amount of dentin left at the coronal level and time until failure. Consequently, it might also be speculated that the influence of the amount of dentin left at the coronal level as (significant) predictor might vary when the newest classification would have been used in the present study. Furthermore, it might be speculated that due to the relatively low number of failures in the present study, no significant association could be revealed.

One limitation of this study is the lack of a priori sample size calculation. Before the beginning of the present study, no clinical study and only a few in vitro studies [11] on ETT without post placement were published. Thus, the calculation of effect sizes between different treatment options seemed unadvisable. However, available clinical studies on ETT with post placement included up to 150 posts to identify risk factors for restoration failure [26, 27]. Thus, in the present study, it was intended to include a minimum of 150 coronal restorations on ETT without post placement. Finally, more than 190 coronal restorations could be included. Nonetheless, the present study may still be underpowered to detect moderate to clinically significant relative risks because of the small number of failures being observed. For example, considering an α-error of 25% (bivariate analysis) and a HR of 0.7 (being the HR between incisors and canines) approximately 130 incisors and 100 canines (ratio of incisors and canines in the present study) had to be enrolled to provide a power of 80%. Consequently with a larger sample size and hence more failures, the influence of some factors as (significant) predictor would probably increase.

In the present study, the longevity of composite build-ups was not significantly affected by the tooth type. This is in contrast to the results of previous studies on posts. Higher failure rates for restorations of anterior teeth (incisors/canines)

Table 2 Multivariate Cox proportional hazard regression analyses of time until failure as function of baseline characteristics identified

Category	*p* value	HR	95% CI
Dentist			
1		1.0	Reference
2	0.492	2.2	0.2–22.6
3	0.700	1.4	0.3–7.4
4	0.753	0.8	0.2–3.7
5	0.462	0.3	0–6.2
6	0.772	0.6	0–13
7	0.856	0.9	0.2–4.5
Proximal contacts			
1		1.0	Reference
2	0.438	1.8	0.4–8.2
Grade of coronal destruction			
Build-up without contact to the gingiva		1.0	Reference
Build-up with contact to gingiva	0.153	0.4	0.1–1.4
Build-up subginvial	0.871	1.1	0.4–3.4
Number of restored tooth surfaces			
1–2 surfaces		1.0	Reference
3 surfaces	0.575	0.7	0.3–2.1
≥ 4 surfaces	0.749	0.8	0.2–2.8
Adhesive			
Two-step etch and rinse adhesive		1.0	Reference
Other adhesive	0.524	2.0	0.2–17.1

compared with posterior teeth (premolars/molars) were observed [1, 9, 27]. The contrary results might be based on the low number of overall failures as discussed above. However, since main biomechanical factors for the fracture risk of ETT are non-axial forces [28], the findings of the previous studies can also be explained by the higher horizontal forces acting on anterior teeth compared with the more perpendicular compressive forces acting on posterior teeth [27, 29]. Furthermore, in ETT with posts, non-axial forces are transmitted along the length of the root—enhancing the stress concentration on the root dentin [30]—whereas little or no (non-axial) forces are transmitted in ETT when no posts are placed [30]. In consequence, a relatively higher increase in the failure rates of anterior teeth compared with posterior teeth can be observed after post placement, whereas no relative increase can be observed when no post is placed. Thus, the longevity of composite build-ups is not significantly affected by the tooth type.

Previous studies showed that "post/no post placement" is not the only significant predictor for time until failure. For restorations including a post placement, the preparation of a circumferential dentin collar of at least 1.5–2 mm in height (ferrule design) is also associated with a longer time until failure [7, 31]. Even for the comparison of post vs. no post placement, the ferrule design seems to be a predominant factor [10]. In vitro, no significant difference in the load resistance could be observed between non-ferrule-supported posts and composite build-ups, whereas a significantly higher load resistance was revealed for ferrule-supported posts when compared with composite build-ups [10]. Interestingly, ferrule-supported composite build-ups were not analyzed in the mentioned study. Consequently, it might be speculated that no significant difference in the load resistance would be observed when ferrule-supported composite build-ups (without post placement) would be compared with ferrule-supported posts. Furthermore, in the present study, it would have been informative, if a ferrule design was prepared or not. Since the relevance of the ferrule effect for ETT with posts (and without posts) was evaluated in the literature after the beginning of the present study, no data on the presence or absence of a ferrule design were collected when build-ups were inserted.

In the present study, the most frequent mode of failure was build-up fracture ($n = 15$). However, only two of the 15 teeth had to be extracted. Due to recementing or renewing of the build-ups, the other 13 teeth were still in function at the end of the observation period. When including the longitudinally fractures of the teeth—being most probably related to the build-up—five catastrophic failures could be observed after 10 years. Thus, the low number of catastrophic in relation to the number of non-catastrophic failures indicates that avoiding post placement in ETT is a viable option when restoring these teeth.

The seven dentists in the seven dental practices were recruited from a practice-based research network. In general, in this network treatment, decisions and processes are coordinated to evaluate and compare the quality of work as well as to receive feedback from colleagues. Furthermore, prior to this study's criteria for inclusion, failure, success/survival as well as treatment decisions/processes, reintervention, and documentation for this study were calibrated. Nonetheless, due to the nature of this study, effects of different operators on the judgment of the treatment outcome cannot be completely excluded since assessment of the status of the build-up was done by the dentist who placed the build-up and not by a second blinded dentist. This, of course, may cause difficulties to control bias and confounders. However, the success of the examiner calibration can presumably also be seen in the results of the present study. The longevity of the composite build-ups was not significantly affected by the dentists. Thus, the present study setting not only reflects the real clinical situation but is also closer to daily clinical routine in dental practices than university-based studies.

In conclusion, relative low annual failure rates (2.4%) could be found for composite build-ups in ETT without post placement. Thus, the chosen treatment decisions resulted in successful restorations of incisors, canines, and premolars in a private-practice setting after a follow-up of 10 years.

Furthermore, within the limitations of the present study (e.g., small sample size), none of the analyzed factors such as tooth type or number of restored tooth surfaces was a significant predictor for the failure rate. Thus, the clinical routine of placing posts in ETT should be critically revised.

Acknowledgements The authors are grateful to the dental practitioners who treated the patients and provided their data.

Author contributions E.K. and the network Arbeitskreis Zahnärztliche Therapie designed and planned the study; R.J.W., E.K., T.G.W., M.N., and H.M.-L. designed the study evaluation; E.K. provided the patient files; R.J.W. and T.G.W. performed the statistical analysis; R.J.W. and H.M.-L. wrote the manuscript; and E.K., T.G.W., and M.N. revised the manuscript.

Funding This study was funded by the authors and their institution.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interests.

Ethical approval This study was a prospective, non-interventional, multi-center, clinical study without the need for local review board approval according to ethical committee of the Medial Chamber of Lower Saxony. This study conforms to the STROBE guideline for cohort studies [19]. The study has been registered in the German Clinical Trials Register (DRKS-ID: DRKS00012882).

Informed consent For this type of study, formal consent is not required.

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