Long-term Clinical Outcomes of Endodontically Treated Teeth Restored with or without Fiber Post–retained Single-unit Restorations

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Abstract

Introduction: The aim of the present study was to evaluate both survival and failure rates of endodontically treated teeth restored with or without fiber post–retained restorations after a mean observation period of at least 5 years. Methods: A total of 144 single-rooted and multirouted teeth in 100 subjects were endodontically treated following a predetermined aseptic protocol and restored with either a fiber post and a composite core or a composite filling without intraradicular retention. A fiber post was cemented when the teeth presented with only 1 wall and/or less than one third of the remaining height of the clinical crown. After a comprehensive treatment plan, the teeth were restored with either a direct composite restoration or a single-unit crown. Endodontically treated teeth supporting fixed and removable dental prostheses and telescopic crowns were excluded from the analysis. Success was defined as tooth survival without any treatment of biological and/or technical complications. Results: The overall tooth survival rate was 89.6% after a mean observation time of 8.8 ± 2.3 years. The survival rate of teeth with a fiber post amounted to 94.3%, and for teeth without a post, it was 76.3% (P < .001). The main reason for tooth loss was root fracture (9.7%). No loss of post retention was observed. Successfully treated teeth without any biological and/or technical complications and requiring no additional treatment during the entire observation period amounted to 79.9%. Conclusions: Endodontically treated teeth restored with fiber posts and either a direct composite restoration or a single-unit crown yielded higher survival and success rates compared with teeth restored without fiber posts. Vertical fractures of roots not containing a post represented a frequently encountered and serious problem. (J Endod 2017;43:188–193)

Key Words
Fiber post, restoration, root canal treatment, root filling, root fracture, single-unit crown

Because of the increasing popularity of implant dentistry, the decision whether to treat or extract severely compromised teeth affected by pulpal and/or periapical disease and considerable loss of coronal tooth substance becomes more challenging. Thorough assessment of the patient’s health and periodontal condition and a careful evaluation of the remaining tooth substance facilitated by magnification devices are important prerequisites in the decision-making process. High-standard nonsurgical endodontic treatment completed by a quality restoration and single-tooth implants both represent viable treatment modalities (1). Both treatment options have risks, advantages, and disadvantages, and patients need to be informed, enabling them to participate in the choice of the proper treatment.

For single-tooth implants, a higher incidence of postoperative complications requiring additional treatment interventions has been reported (2), whereas in most endodontic studies detailed information on the restoration is lacking. Root canal–treated teeth reconstructed with a good restoration show higher success rates (3, 4), and patients prefer keeping their own teeth whenever possible (5).

Because of limited clinical evidence on the influence of restorative procedures on root canal–treated teeth, principles for restorative work have to be mainly derived from laboratory studies. A considerable lack of coronal tooth substance, the presence of a dentin ferrule, careful selection of luting agents for post cementation, and coronal restoration may all influence clinical outcomes (6–10).

In a clinical study following a protocol for high-quality root canal treatment and standardized restoration procedures, the 5-year survival rate of endodontically treated teeth amounted to 92.5% for teeth restored with titanium posts, 97.1% for those restored with cast post and cores, and 94.3% of teeth without post-retained restorations (11). The most frequent complications included root fracture (6.2%), recurrent caries (1.9%), development of periapical pathology (1.6%), and loss of retention (1.3%). Similar cumulative survival rates and frequency of root fractures, increased probing
depths, increased tooth mobility, caries, periapical lesions, and loss of retention were reported for endodontically treated teeth restored with either indirect cast post and core or direct composite buildups with titanium posts after a mean observation period of 8.56 years (11).

Moreover, outcomes of a recent systematic review indicated similarities between the incidences of root fractures among metal and fiber post–retained restorations after an observation period of at least 5 years (12). However, the studies included in the systematic review (12) presented a high risk of bias without being able to formulate clear guidelines for the selection of metallic versus fiber posts.

Today, fiber-reinforced, resin-based composite posts with a modulus of elasticity similar to dentin are supposed to significantly reduce the risk of vertical root fractures. Most common causes of failure associated with fiber posts are post debonding, secondary caries, and restorable cervical fractures (13–15), with post debonding being the major role of failure (16). Laboratory studies have identified debonding being caused by difficulties in regarding dentin hybridization (17). Removal of the thick smear layer produced during post space preparation is critical for a good retention of adhesively luted posts (18). In most clinical studies, detailed information on post space preparation and bonding procedures is missing.

Aware of the advantages of fiber posts and the inherent problems regarding debonding of adhesively luted reconstructions, endodontically treated teeth included in the present study were restored according to a protocol respecting available evidence of laboratory work (19).

For the purpose of the present study, success was defined as tooth survival without any treatment of biological and/or technical complications. Therefore, the aim of the present study was to assess success, survival, and failure modes of endodontically treated teeth restored with or without fiber posts and either direct composite restorations or single-unit crowns after an observation period of at least 5 years.

**Material and Methods**

**Null Hypothesis**

The null hypothesis of the present investigation was that no differences in survival and success rates of endodontically treated teeth restored with or without a fiber post would be observed.

**Study Design**

No preliminary data were available for this study. Hence, it was not possible to perform a sample size calculation with respect to the difference in outcome variable. This study was designed and conducted as a longitudinal retrospective evaluation of endodontically treated and restored teeth with an observation period of at least 5 years. The endodontic and restorative procedures were performed by 1 specialist in periodontology and endodontology (B.E.S.G.) in a private practice in Bern, Switzerland, as part of standard dental care. A standardized protocol was followed in order to optimize endodontic and restorative procedures. The study was conducted observing the guidelines for clinical research in the Declaration of Helsinki.

Inclusion criteria were as follows:

1. Subjects without relevant medical conditions;
2. Completion of periodontal treatment with a full-mouth plaque score \( \leq 30\% \) and a full-mouth bleeding score \( \leq 30\% \);
3. Regular compliance with a supportive periodontal therapy program;
4. Possibility to check the restored abutment teeth with respect to biological (ie, recurrent caries, recurrent periodontitis, and periapical pathology) and/or technical (ie, loss of retention, post fracture, and root fracture) complications, respectively; and
5. Single- and multirooted teeth serving as abutments for either a single-unit metal ceramic crown or a direct composite crown.

Exclusion criteria were as follows:

1. Subjects with untreated periodontal conditions and
2. Endodontically treated teeth supporting removable dental prostheses, telescopic crowns, and fixed dental prostheses.

**Endodontic and Restorative Procedures**

Root canal treatment or retreatment was performed on all teeth after rubber dam isolation (Ivory; Heraeus Kulzer GmbH, Hanau, Germany) and standardized chemical (ie, irrigations with 0.5% sodium hypochlorite) and mechanical disinfection with hand (ie, FlexoFiles; Dentsply Maillefer, Ballaigues, Switzerland) and rotating instruments (Lighspeed LS1; Lightspeed Technology, San Antonio, TX, and Protaper Universal; Dentsply Maillefer, Ballaigues, Switzerland). Root canal obturation was performed by means of lateral condensation with gutta-percha points and a root canal sealer (AH Plus; Dentsply DeTrey GmbH, Konstanz, Germany). The use of an additional light source and magnifying loupes (3.5x; Zeiss, Feldbach, Switzerland) or a microscope (Global Surgical Corporation, St Louis, MO) was part of the standardized endodontic and restorative protocol. To minimize the risk of recontamination, permanent closure of the access cavity was performed under rubber dam isolation and within 2 to 3 weeks after root canal obturation. In teeth with only 1 wall and/or less than one third of the remaining height of the clinical crown according to Perez et al’s class IV and V (20), a fiber post (Easy Post and Easy Post Lux, Dentsply Maillefer) was cemented in the strongest root (eg, the distal root of the lower molars or the palatal root of the upper molars).

After initial post space preparation to a depth of 8 mm from the canal entrance by means of a Largo Peeso Bur (Dentsply Maillefer, Ballaigues, Switzerland) with a noncutting tip to avoid root perforation, the precision drills were used by hand, and, if necessary, a matrix band was placed. In case of short roots, care was taken to leave an apical seal of at least 3- to 4-mm root filling, and, if necessary, a shorter post was used.

The smear layer in the post space and the access cavity was removed with a rotating brush (Curaden, Kriens, Switzerland) and a chelating solution (Tubulicid; Dental Therapeutics AB, Saltsjö–Boo, Sweden). Etching of the access cavity and post space with 36% phosphoric acid for 30 seconds (Blue Etch; La Maison Dentaire SA, Balzers, Lichtenstein) was followed by rinsing with water for 60 seconds and air drying. Irrigation with alcohol, air drying, and visual inspection for cleanliness using a microscope were followed by dentin conditioning (Syntac Primer, Syntac Adhesive) and application of bonding resin (HelioBond). Excess material was removed from the post space by means of sterile paper points.

The post was cleaned with alcohol, and silane (Monobond S/Monobond Plus; Ivoclar Vivadent, Schaan, Lichtenstein) was applied for 60 seconds. After application of bond resin to the post, a thin layer of cement was brought into the canal space using a Lentulo spiral (Dentsply Maillefer) and on the post before insertion. The core was built with adding composite material in increments according to the manufacturer’s instructions (Saremco ELS, Rebstein, Switzerland).

**Biological Complications**

Biological complications of abutment teeth were recorded as endodontic failure, recurrent caries, or recurrent periodontitis.

**Technical Complications**

Technical complications of abutment teeth were recorded as loss of retention or root fracture.
Abutment Tooth Survival

Abutment tooth survival was defined as teeth surviving without any treatment needs and teeth surviving after treatment of biological and/or technical complications.

Abutment Tooth Success

Abutment tooth success was defined as teeth surviving without any treatment of biological and/or technical complications.

Statistical Analysis

Descriptive statistics are presented as mean ± standard deviations and ranges with intervals. The tooth was used as the statistical unit. Chi-square and Fisher exact tests were applied to detect statistically significant differences between groups. A P value < .01 was considered statistically significant. Statistical analysis was performed with a commercially available software package (SAS Institute Inc, Cary, NC).

Results

Eighteen of 144 teeth (12.5%) in 15 patients were lost to follow-up because of the following reasons: lack of radiographs at follow-up (n = 10), relocation (n = 6), and treatment plan change (n = 2). The mean observation time was 8.8 years with a median of 8.7 years and a range of 5.1–15.3 years (Table 1).

Table 2 shows the frequency distribution of restorations with respect to retention and tooth type. The percentage of teeth restored with a fiber post included 25.5% incisors and canines (n = 27), 32.1% premolars (n = 34), 21.7% maxillary molars (n = 23), and 20.8% mandibular molars (n = 20), respectively. Teeth without post-retained restorations included 28.9% incisors and canines (n = 11), 15.8% premolars (n = 6), 31.6% maxillary molars (n = 12), and 23.7% mandibular molars (n = 9), respectively.

The overall tooth survival rate was 89.6%. The survival rate was 94.3% for teeth with a fiber post and 76.3% for teeth without a post, respectively (Table 3). As shown in Table 3, 106 teeth (73.6%) were restored with a fiber post and either a single-unit crown (SUC) or a direct composite restoration (DCR). Teeth without a post (n = 38, 26.4%) were restored either with an SUC or a DCR. Teeth restored with a fiber post yielded a statistically significantly (P < .001) higher survival rate compared with teeth restored without a post, irrespective of the restoration type. Similarly, teeth restored with a fiber post yielded a statistically significantly (P < .001) higher success rate compared with that of teeth restored without a post, irrespective of the restoration type (Table 3).

With respect to the survival and complication rates, no statistically significant differences (P > .05) were observed comparing non-crowned teeth (ie, with DCRs) with and without a fiber post with crowned teeth (ie, with SUCs) with and without a fiber post (Table 3). In teeth with post-retained restorations, no loss of post retention and no post fracture were observed, irrespective of the restoration type. In 9.7% (14/144) of all teeth, vertical root fracture was the reason for tooth loss. In 4.9% (7/144) of all teeth, vertical root fractures were observed in maxillary and mandibular molars subsequently treated with root amputations (Table 4).

As shown in Table 5, of a total of 21 (14.6%) vertical root fractures, only 1 fracture occurred in a root containing a post. Of all the vertical root fractures, 52.4% (11/21) were observed in the mesial roots of mandibular molars without a post.

Discussion

The present study assessed the survival and success rates of endodontically treated teeth restored with or without fiber posts and either DCRs or SUCs over a mean observation time of 8.8 years. The results indicated that endodontically treated teeth restored with fiber post–retained restorations yielded statistically significantly higher survival and success rates compared with those of teeth without a post. Moreover, the fact that endodontically treated teeth with and without a fiber post were crowned did not improve the prognosis when compared with that of noncrowned teeth. Thus, based on these outcomes, the null hypothesis was rejected.

The results of the present study are corroborated by findings of a randomized clinical trial indicating that the placement of a prefabricated or customized fiber post contributed significantly to the survival of endodontically treated premolars restored with an SUC over an observation period of 6 years (15). In contrast with the outcomes of the study by Ferrari et al (15), no operator variability, post debondings, or post fractures were observed in the present study. It has to be noted that all the endodontic treatments were rendered by the same specialist in endodontology and periodontology under a strict standardized protocol. However, additional differences were observed when comparing the protocol of the present study with that of Sterzenbach et al (8) in which only teeth with a dentin ferrule of at least 2 mm were used as abutments for SUCs and fixed and removable dental prostheses. Hence, based on the fact that different endodontic and restorative protocols were adopted among studies, a full comparison with the study outcomes by Ferrari et al (15) and Sterzenbach et al (8) must be exercised with caution.
Nevertheless, despite the fact that endodontically treated teeth were restored adopting different protocols, the outcomes reported in the present study and in those discussed previously (8,15) yielded favorable survival rates of approximately 90% after an observation period of 6 to 9 years. As such, endodontic therapy has to be accepted as being predictable and reliable. A survival rate of endodontically treated teeth of approximately 90% compares favorably with that of 95.2% of implants supporting SUCs after 10 years (21). Furthermore, in a study assessing the quality of life of patients with either endodontically treated teeth or implant-supported restorations, all participants expressed a clear message toward the retention of their natural dentition (5). Thus, prophylactic extractions of endodontically treated and restored teeth being replaced with dental implants cannot be recommended.

Bonding to root canal dentin is challenging and influenced by multiple factors (19,22,23). Dowel debonding appears to be a frequently reported mode of failure in previously published clinical trials on adhesively luted fiber posts (7,14,16,24). In contrast to the findings of the studies mentioned previously, no loss of post retention was observed in the present study, corroborating the results of a study reporting on the long-term survival rate of endodontically treated maxillary incisors restored with fiber posts and SUCs (25). As in the present study, post space preparation and post placement were performed under a rubber dam; special attention was given to careful removal of the smear layer and cementation. Because of the heterogeneity of treatment protocols and the lack of detailed information on the clinical procedures applied, reasons for the controversial results can only be speculated on. Nevertheless, the presence of a special smear layer existing after post space preparation (26) has to be given appropriate attention.

The results of the present study are in agreement with those of Mannocci et al (27), who reported similar survival rates of teeth restored with a fiber post and direct composite restorations compared with crowned teeth (SUC) with a fiber post and a composite core. However, it has to be noted that the observation time of the study by Mannocci et al was 3 years, whereas the observation time of the present study amounted to 10.3 years for DCRs and 8.1 years for SUCs. Also, when comparing DCRs with SUCs, no statistically significant difference in survival rates was observed for teeth restored without a fiber post, supporting the hypothesis of Mannocci et al that full-crown coverage does not result in better clinical performance, even after observation periods of 8 to 10 years.

Recently, a systematic review on the effect of post placement on the restoration of endodontically treated teeth was published (28). Based on 2 studies (15,29), the authors concluded that post placement appears to have a significant influence in reducing the failure rate leading to extraction of endodontically treated teeth. In agreement with these findings, the data of the present study show that teeth restored with fiber posts yielded significantly less tooth loss than teeth restored without a post, irrespective of the presence or absence of an SUC.

Focusing on complications, 14.6% of vertical root fractures defined according to the American Association of Endodontics (30) accounted for the most frequent events observed. The occurrence of vertical root fractures has been reported with a range from 3.1% up to 20% (31).

The fact that, in the present study, only 1 of these fractures occurred in a root containing a post (Table 5) deserves special attention. Most fractures were diagnosed in mesial roots of mandibular and mesiobuccal roots of maxillary molars not containing a post. This is in disagreement with many studies published on this topic. In fact, reasons held responsible for vertical root fractures and of which the operator was well aware were lack of residual tooth substance, obturation methods (32), chemical influence of irrigation solutions, intracanal medications (33), and excessive occlusal forces (34). In order to prevent excessive occlusal forces, patients of the present study were instructed to report on potential occlusal prematurities, and the situation was immediately corrected.

### TABLE 3. Survival, Success, and Tooth Loss with Respect to Retention and Restoration Type

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<td>Fiber post, n (%)</td>
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<td>Retention</td>
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DCR, direct composite restoration; SUC, single-unit crown.

*94.3% statistically significantly different from 76.3% (P < .001).
†85.8% statistically significantly different from 63.2% (P < .001).
The special anatomy of mesial roots of mandibular molars containing 2 root canals often connected by the presence of an isthmus (35) has been addressed by Chai and Tamse (36) applying a 2-dimensional mechanical fracture analysis. The isthmus between the 2 root canals, the hourglass shape, and the curvature of these roots seem to significantly weaken the root and may be an additional explanation for the increased occurrence of vertical root fractures in mesial roots of mandibular and maxillary first molars in the data of the present study.

The fact that all treatments were performed by the same operator may be interpreted as a strength of the study. It reflects a proof of principle approach not disturbed by operator variability. Obviously, random treatment allocation was not possible. Immediately after completion of the endodontic treatment, teeth characterized by extensive periapical radiolucencies and severe coronal destruction were restored with a post and a DCR to prevent reinfection. As soon as healing of the periapical lesion was diagnosed on the radiographs, SUCs were fabricated. It is well-known that healing of large periapical lesions can take up to 4 years (37). After a long healing period, many patients with a well-functioning DCR refused to have further treatment, explaining the reduced number of SUCs. Therefore, a sample size calculation could not be performed, which may be considered a weakness of the present study.

In conclusion and within the limits of the present study, the data show the following:

1. The presence or absence of a fiber post in endodontically treated teeth of patients enrolled in regular maintenance care yielded good long-term survival rates, irrespective of the presence or absence of an SUC.
2. Fiber posts did not weaken the roots of endodontically treated teeth.
3. Vertical fractures of roots not containing a post were the most frequently encountered complication; and
4. Vertical fractures of roots not containing a post represented a serious problem, which needs to be evaluated in further clinical trials.

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The authors deny any conflicts of interest related to this study.

References


