Clinical Performance of Fiber Post Restorations in Endodontically Treated Teeth: 2-Year Results

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Purpose**:* This study evaluated the 2-year outcome of post-and-core restorative procedures in endodontically treated teeth. The effect of baseline factors (tooth type, number of residual coronal walls, and type of definitive restoration) on restoration failure was assessed. ***Materials and Methods: The consecutive sample design included 150 patients. A total of 162 teeth (57 anterior and 105 posterior) were restored. Sixty-nine teeth had 3 or 4 residual coronal walls, while 93 teeth had 2 or fewer walls. Crowns and direct resin composite restorations were placed in 121 and 41 teeth, respectively. After 23 to 25 months, all patients were evaluated. Logistic regression was used to identify the joint effect of variables recorded at baseline ($P < .05$). ***Results**:* The only failure modes observed were post debonding (4.3%, 2 in anterior teeth and 5 in posterior teeth) and endodontic failure (3.0%, 2 in anterior teeth and 3 in posterior teeth). All post debondings occurred in teeth with 2 or fewer coronal walls that were crown covered. All endodontic failures occurred in crown-covered teeth (1 failure in a tooth with 3 walls and the remaining 4 failures in teeth with 2 or fewer walls). Logistic regression found no statistical significance for any of the variables recorded at baseline. ***Conclusion:*** Restorations placed with the use of a fiber post and core resulted in 4.3% post debondings and 3.0% endodontic failures after 2 years of clinical service. *Int J Prosthodont 2007;20:293–298.*

Literature on the performance of fiber post-and-core systems is constantly increasing.[1,2] The potential of these systems to reduce the incidence of nonretrievable root fractures when compared to conventional cast posts has been emphasized in several in vitro studies.[3–8]

The significance of laboratory findings was confirmed in many clinical studies showing satisfactory performance of endodontically treated teeth restored with post-and-core systems. Both retrospective[9–11] and prospective[12–17] clinical studies have been conducted, focusing on different aspects of restorative procedures involving placement of fiber posts. Survival rates reported in these studies vary substantially, and this heterogeneity can be attributed partly to different study designs, inclusion criteria, number of patients followed, and observation periods. Nevertheless, valuable information has been obtained, providing the opportunity to identify major decision-making elements in restoring endodontically treated teeth with and without post placement.[2]

Factors that can affect the survival of endodontically treated teeth are numerous and diverse. An investigation of the influence of proximal contacts revealed that teeth with no or 1 proximal contact at access were lost at more than 3 times the rate of teeth with 2 proximal

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Table 1 Distribution of Treated Teeth, No. of Residual Coronal Walls, and Crown Placement

No. of walls	Anterior	Posterior	Total
No walls			
Crown	26	30	56
1 wall			
Crown	4	10	14
No crown	3	–	3
2 walls			
Crown	–	13	13
No crown	7	–	7
3 walls			
Crown	–	15	15
No crown	–	13	13
4 walls			
Crown	5	18	23
No crown	12	6	18

contacts.[18] A strong association was also found between crown placement and the survival of endodontically treated teeth.[19]

However, studies that specifically identify tooth-related factors as possible failure predictors of fiber post restorations in endodontically treated teeth are missing in the literature. In prospective studies, only 1 type of tooth has been included.[12,15] Various retrospective studies provided information on both maxillary and mandibular anterior and posterior teeth, but the number of baseline factors recorded varied and their correlation with the restoration performance was not investigated.[9–11] In the only study that evaluated risk factors for fiber post restoration failure, tooth type, type of definitive restoration, and the presence of adjacent teeth were found to be significant predictors of failure.[17]

The aim of the present study was to evaluate the 2-year outcome of restorative procedures involving the placement of fiber posts in endodontically treated teeth. The null hypothesis tested was that tooth type, number of residual coronal walls, and placement of a crown do not significantly influence failure of a fiber post system placed in an endodontically treated tooth.

Materials and Methods

The study population comprised 150 consecutive patients that needed restoration of endodontically treated teeth between February and July 2003 at the Department of Restorative Dentistry of the University of Siena, Italy. The study protocol was reviewed and approved by the Ethical Committee of the University of Siena. All patients needing restoration of endodontically treated teeth were included until 150 patients were collected. Patients that presented with previously endodontically treated teeth and patients in whom endodontic treatment was needed prior to the restoration were both included. A total of 162 teeth were restored by 2 operators. If the teeth had already been endodontically treated, inclusion criteria of a symptom-free root canal filling with a minimum apical seal of 4 mm had to be met. Only teeth that had been previously endodontically treated by 1 of the 2 operators were included in the study. The age of the patients ranged from 18 to 75 years (mean: 56 years). Seventy-nine restorations were placed by the first operator and 83 by the second operator. The assignment of each patient to one of the operators was decided by tossing a coin. Both anterior (n = 57) and posterior (n = 105) teeth with varying degrees of hard tissue loss were included in the study. The following data were collected at the baseline examination: patient age and gender, tooth type (anterior or posterior), number of residual coronal walls (0 to 4), size of the post placed, and type of restoration (crown or direct resin composite restoration).

Distribution of treated teeth, number of residual coronal walls, and presence of crowns are shown in Table 1. Sixty-nine teeth had 3 or 4 residual coronal walls, while 93 teeth had 2 or fewer walls. In the molar roots, only 1 post was placed, either in the palatal root of maxillary teeth or the distal root of mandibular teeth. The restorations of 121 teeth were metal-ceramic and all-ceramic crowns. The remaining teeth were restored with direct resin composite restorations.

Clinical Procedures

In teeth that needed endodontic treatment prior to restoration, the roots were endodontically treated using a step-back technique with FlexMasters nickel-titanium instruments (VDW), Gates-Glidden drills (nos. 1 to 3, Union Broach), and 2.5% sodium hypochlorite irrigation. The canals were obturated with thermoplasticized injectable gutta-percha (Obtura, Texceed) and a resin sealer (AH-Plus, DeTrey). No less than 48 hours after endodontic treatment, the roots were prepared to receive a post.

DT Light Posts (RTD) were used (nos. 1 to 3 based on the size and shape of the roots). After selection of the appropriate drill size, the root canal space was prepared using preshaping and finishing drills provided by the manufacturer to a length of 8 mm. At least 4 mm of gutta-percha was left apically to seal the root apex. The posts were tried in and consequently shortened with a diamond bur. The cementation procedure was performed according to the manufacturers' instructions. Prime & Bond NT Dual Cure adhesive system (Dentsply Caulk) was used in combination with dual-cure resin cement (Calibra, Dentsply Caulk). The post space was rinsed and thoroughly dried using air and paper points.

Caulk 34% Tooth Conditioner Gel (34% phosphoric acid, Dentsply Caulk) was applied to the post space through a needle and completely rinsed off after 15 seconds with water carried into the canal using an endodontic syringe. Excess water was removed from the post space with a gentle air blast. Paper points were used to remove residual moisture without desiccating the etched dentin surface. One to 2 drops of Prime & Bond NT adhesive were placed into a clean plastic mixing well and immediately mixed with an equal number of drops of self-cure activator for 1 to 2 seconds with a clean, unused brush tip. The adhesive/activator mixture was applied to the post preparation with a microbrush, and care was taken to apply generous amounts to the preparation orifice. The contact of the adhesive/activator with the tooth structure was maintained for 20 seconds. The post preparation was dried with an air syringe, and the excess adhesive/activator solution was absorbed from the post space with a paper point. A single coat of mixed adhesive/activator was applied to the post with the same brush, followed by gentle air drying. If any non-shiny areas appeared on the treated post, the mixed adhesive/activator was reapplied and immediately air dried for 5 seconds. Resin cement components were mixed and spread on the surface of the post and into the post preparation with a lentulo spiral. The post was seated immediately, and the excess cement was removed. Light curing was performed on the post for 10 seconds with a high-power light-emitting diode curing light (950 mW/cm^2, SmartLite PS, Dentsply Caulk). Buildup of the abutment cores prior to crown coverage was performed using flowable resin composite (X-Flow, Dentsply Caulk) and microhybrid resin composite (CeramX, Dentsply Caulk). The same resin composites were used for placing direct resin composite restorations.

In teeth restored with crowns, care was taken to prepare a 2-mm-high ferrule. However, in several teeth, nonuniform ferrules had to be prepared because of a loss of tooth structure. In these cases, the achieved ferrule height was never below 1 mm. All-ceramic crowns were fabricated using the IPS Empress System (Ivoclar Vivadent).

Evaluation Parameters

After 23 to 25 months, all patients were recalled for a follow-up evaluation. The success rate was assessed by clinical and intraoral radiographic examinations. Radiographs of each fiber post were taken with the long-cone technique using ultraspeed film. A modified parallel technique was used. The radiographs were examined at approximately 5× magnification. Failure was defined as the need for a new restoration because of post debonding, post fracture, vertical or horizontal root fracture, or a failure of the core buildup. Endodontic problems requiring retreatment were also noted; however, the primary goal of the study was to assess factors related to the success/failure of the fiber post restorative procedure rather than the endodontic treatment. Further, since endodontic failures cannot be directly attributed to the post-and-core system, they were not included in the statistical analysis. Clinical examinations were carried out independently by the 2 operators, and the examiner was always the operator who did not place the restoration.

Statistical Analysis

To aid in the analysis, the dependent variable (outcome of fiber post restorative procedure) was dichotomized (success/failure). The chi-square test was applied to investigate whether the 2-year outcome of the restorative procedure presented with significant differences between the 2 operators. A logistic regression model was used to identify the joint effect of variables recorded at baseline that could have modified the occurrence of restoration failure. The level of significance was set at $P < .05$. Calculations were performed using SPSS 13.0 software (SPSS).

The data obtained in the study were also used to perform a power analysis to determine how many subjects would be necessary to show the statistical significance of baseline parameters when various response rates of the dependent variable were assumed, given the standard values of power (80%) and type I (5%) and type II (20%) errors. These calculations were handled by PASS Power Analysis Software (NCSS).

Results

Results of the 2-year recall are summarized in Table 2. No root or post fractures and no failures of the core buildup were recorded. The only failure mode observed was post debonding (7 cases, 4.3%). Three debondings occurred in teeth restored by the first operator, and 4 in teeth restored by the second operator. In all cases, post debonding occurred in crown-covered teeth. Two post debondings were recorded for anterior teeth, both in cases where the restored tooth had no remaining coronal walls prior to treatment. In posterior teeth, 5 post debondings occurred, also in cases with a considerable amount of tooth-structure loss.

No statistically significant differences were found in the number of restoration failures between the 2 operators. Logistic regression analysis found no statistical significance for any of the variables recorded at baseline. Therefore, no factors were identified as possible predictors for fiber post failure. All restorations that failed as a result of post debonding were replaced in the same manner as previously described.

Table 2 Outcome of the 2-Year Evaluation of Placed Restorations: Post Debonding

	Anterior	Posterior	Total
No walls			
Crown			
Debonding	2	2	4
Success	24	28	52
1 wall			
Crown			
Debonding	–	2	2
Success	4	8	12
No crown			
Success	3	–	3
2 walls			
Crown			
Debonding	–	1	1
Success	–	12	12
No crown			
Success	7	–	7
3 walls			
Crown			
Success	–	15	15
No crown			
Success	–	13	13
4 walls			
Crown			
Success	5	18	23
No crown			
Success	12	6	18

Table 3 Outcome of the 2-Year Evaluation of Placed Restorations: Endodontic Failures

	Anterior	Posterior	Total
No walls			
Crown			
Failure	1	–	1
Success	25	30	55
1 wall			
Crown			
Failure	1	2	3
Success	3	8	11
No crown			
Success	3	–	3
2 walls			
Crown			
Success	–	13	13
No crown			
Success	7	–	7
3 walls			
Crown			
Failure	–	1	1
Success	–	14	14
No crown			
Success	–	13	13
4 walls			
Crown			
Success	5	18	23
No crown			
Success	12	6	18

In cases of endodontic failure (5 cases, 3.0%), the teeth presented with asymptomatic periapical lesions. Two failures were recorded for anterior teeth and 3 for posterior teeth (Table 3). All endodontic failures occurred in crown-covered teeth (1 failure in a tooth with 3 walls and 4 failures in teeth with 2 or fewer walls). After retreatment, the restorations were replaced and the teeth remained in service.

Power analysis revealed that for the observed percentage of failures (4.3%), a sample size of 82 patients is needed to detect the statistical significance of baseline variables. When the calculations were performed assuming a higher percentage of failures, the sample size increased as the assumed percentage of failures increased. The analysis indicated that the sample size of 151 patients would be sufficient to detect statistical significance if the percentage of failures was 30%.

Discussion

None of the variables recorded at baseline were found to have a significant influence on fiber post restoration failure, which led to acceptance of the null hypothesis.

All 7 post debondings occurred in teeth that were restored with crowns, while no failures were seen in teeth restored with fiber posts and direct resin composite restorations. However, the majority of teeth in this study were restored with crowns (121, 74.7%). Also, 83 (68.6%) crown-covered teeth had 2 or fewer coronal walls prior to treatment, and all post debondings occurred in teeth with these characteristics.

The percentage and nature of failures are in accordance with a previous retrospective study in which all debondings occurred in cases where posts were bonded to teeth with less than 2 mm of remaining coronal dentin.[11] A higher failure rate (7.7%) was recorded in a prospective study in which all the included teeth had lost more than 50% of their coronal structure.[14] On the other hand, a failure rate of 12.8% was reported in a prospective study after 24 months.[16] Nevertheless, the most common failure observed in that study was post fracture, which may be related to the rather low fatigue resistance of the posts used.[20] Interestingly, the majority of failures occurred in teeth that had no vertical cavity walls (12 of 16) or 1 wall (3 of 16) at the time of restoration placement, although statistical analysis failed to show the significance of this finding. Conversely, the satisfactory fatigue resistance[20] of posts used in the present study may partly explain the difference in clinical behavior, including the lower percentage of failures in general and complete absence of post fractures. DT Light Posts also showed favorable 2-year results in a prospective clinical study that included premolars with 2 coronal walls.[15] The percentage of debondings and endodontic failures was in accordance with the present study.

Direct resin composite restorations were placed in 41 teeth. Thirty-one (75.6%) direct restorations were placed in teeth with 3 or 4 walls remaining prior to treatment, which may explain the favorable results. Good clinical performance of endodontically treated teeth restored with fiber posts and direct resin composite restorations was reported in a prospective 30-month study.[21] In a retrospective study, Nagasiri and Chitmongkolsuk[22] investigated the survival of endodontically treated molars without crown coverage. It was shown that survival probability increased when a greater amount of coronal tooth structure remained. Molars with maximum tooth structure (4 coronal walls) had a survival rate of 78% at 5 years, and direct resin composite restorations demonstrated better clinical performance than amalgam. Also, in endodontically treated premolars with limited loss of tooth structure (only teeth with Class II cavities and preserved cusp structure were included) fiber posts with direct resin composite restorations showed clinical results comparable to those of full-crown coverage after 3 years of service.[12]

The results of the present study differ from the results reported in a retrospective study comparing fiber-reinforced epoxy resin posts to cast posts and cores.[10] No failures attributed to the post-core procedure were observed at a 4-year recall, although teeth included in the study had a severe loss of tooth structure. Similarly, no failures related to the post-core system were reported in a retrospective study that investigated the use of carbon fiber posts.[9] However, that study did not provide information on the amount of coronal dentin at baseline.

In accordance with a number of studies showing the importance of ferrule effect,[23] Tan et al[24] reported that a nonuniform ferrule results in lower fracture resistance than a uniform 2-mm-high ferrule. Although ferrule height was not one of the factors recorded at baseline in the present study, the authors speculate that the occurrence of nonuniform ferrules caused by loss of tooth structure may have influenced the results.

The nature of failures in the present study confirms the common assumption that bonding to root canal dentin is a difficult task. Stresses from polymerization shrinkage in dowel space complicate the formation of high-strength bonds when cementing endodontic posts with resin cements.[25,26] Debonding of the adhesive from the resin-infiltrated dentin area and debonding of the resin cement from the adhesive are possible failure modes that may occur even when the restoration seems to be clinically in service.[27] Further, a concept of frictional retention has been proposed as a possible predominant explanation for the clinical success of adhesively cemented fiber posts.[28,29]

The amount of remaining coronal dentin prior to the placement of post-and-core restorations is rarely reported in the literature. A tendency of failure to occur in teeth with a high degree of tissue loss at baseline was noticed in this study, and this finding is in accordance with the findings of Naumann et al.[16,17] Although a statistically significant influence was not found, the authors of the present study believe that this topic deserves further investigation, along with other possible risk factors present prior to the placement of post-and-core restorations.

The inability of the applied statistical test to identify any significant effect may be predominantly related to the relatively rare occurrence of failures and the short observation period. With the present distribution of baseline and dependent variables, the sample size was sufficient for finding statistical significance; however, 2 years is a relatively short period from a clinical standpoint. Assuming that the percentage of failures would increase after a longer observation period, it may be speculated that the outcome of the statistical analysis would be different when examining possible risk factors. Also, a study with a larger sample size and longer observation period may allow evaluation and identification of the main reasons for restoration failure, thus providing important information for treatment planning and decision making. Future studies must also assess the significance of additional baseline characteristics, particularly ferrule height, as predictors of the success of fiber post restorations.

Conclusion

Restorations placed using a fiber post and core resulted in 7 cases (4.3%) of post debonding and 5 cases (3.0%) of endodontic failure after 2 years of clinical service.

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Literature Abstract

Insertion torque and resonance frequency analysis of dental implant systems in an animal model with loaded implants

This study aimed to compare the insertion torque and resonance frequency analysis of different implant systems. Three types of Brånemark implants (machined Mk III, TiUnite Mk III, TiUnite Mk IV) and 2 types of Straumann implants (Sand-blasted, large-grit, acid-etched [SLA] and titanium plasma-sprayed [TPS]) were studied. A total of 160 implants, 32 of each type, were placed in healed premolar extraction sites in 16 beagle dogs. One implant of each type was placed in each jaw in a randomized premolar site, resulting in equal distribution between the maxilla and mandible. All implants had a length of 8 mm and a mean standard diameter of 3.8 ± 0.3 mm. The insertion torque was recorded using a torque driver. After a healing period of 8 weeks, the implants were loaded for 3 months, and the animals were then sacrificed. Resonance frequency analysis was performed and implant stability quotients (ISQs) were recorde at placement, after healing, and at the end of the loading phase. All self-tapping implants recorded higher median torque values than the non-self-tapping. No difference was seen between the Brånemark and Straumann implants on the basis of ISQ values at placement. Torque values were classified as high (> 40 Ncm), medium (30 to 40 Ncm), or low (< 30 Ncm). No statistically significant differences in ISQ values were found between the 3 classes. For all implant systems, a significant decrease in median ISQ was observed. ISQ values for self-tapping implants remained stable after loading, whereas the ISQ values for non-self-tapping cylinders decreased. The maximum insertion torque values for failed and successful implants were not significantly different. Significantly higher ISQ values at placement were seen for successful implants (P = .003). Based on this model for ISQ, a threshold of 65.5 was identified, with a sensitivity of 83% and specificity of 61% for prediction of implant loss. ISQ values at the start of loading were not predictive of implant loss in the loading period. The authors concluded that caution should be used when judging implant systems on the basis of resonance frequency analysis and torque measurement.

Al-Nawas B, Wagner W, Grotz KA. *Int J Oral Maxillofac Implants* 2006;21:726–732. **References:** 44. **Reprints:** Dr Bilal Al-Nawas, Oral and Maxillofacial Surgery, J Gutenberg University Hospital Mainz, Augustusplatz 2, D-55131 Mainz, Germany. Fax: +49 6131 17 6602. E-mail: al-nawas@mkg.klinik.uni-mainz.de—*Tapan N. Koticha, National University of Singapore Faculty of Dentistry, Singapore*