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Post Placement Affects Survival of Endodontically Treated Premolars

ABSTRACT

Clinical evidence is lacking regarding the influence of the amount of residual coronal dentin and of post placement on the failure risk of endodontically compromised teeth. The aim of this prospective clinical trial was to assess whether these factors significantly affect the two-year survival of restored pulpless premolars. A sample of 210 individuals provided six experimental groups of 40 premolars in need of endodontic treatment. Groups were defined based on the amount of dentin left at the coronal level. Within each group, in half of the teeth selected at random, a fiber post was inserted inside the root canal, whereas in the remaining half of the premolars, no post was placed. All teeth were covered with a crown. The Cox regression analysis revealed that post placement resulted in a significant reduction of failure risk ($p < 0.001$). Failure risk was increased for teeth under the "no ferrule" ($p = 0.001$) and "ferrule effect" conditions ($p = 0.004$).

KEY WORDS: fiber post, clinical trial, luting, endodontically treated teeth, restoration.

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INTRODUCTION

In recent years, fiber posts have been proposed as a valid alternative to metal posts in the restoration of endodontically treated teeth (Ferrari *et al.*, 2000b; Schwartz and Robbins, 2004). The potential of fiber posts to reduce the incidence of non-retrievable root fractures in comparison with conventional cast posts has been emphasized in several *in vitro* studies (Akkayan and Gulmez, 2002; Fokkinga *et al.*, 2004; Schwartz and Robbins, 2004). Also, in laboratory studies assessing fracture resistance and mode of failure of restored pulpless teeth, post-retained restorations have shown enhanced mechanical resistance and limited occurrence of fatal failures, as compared with teeth restored without posts (Fokkinga *et al.*, 2005; Salameh *et al.*, 2006, 2007; Sorrentino *et al.*, 2007a,b).

Retrospective (Fredriksson *et al.*, 1998; Ferrari *et al.*, 2000a,b, 2007) and prospective (Glazer, 2000; Mannocci *et al.*, 2002; Malferrari *et al.*, 2003; Monticelli *et al.*, 2003; Naumann *et al.*, 2005a,b; Cagidiaco *et al.*, 2007) clinical studies have been conducted to assess the survival of endodontically treated teeth. Due to differences in study design, inclusion criteria, number of individuals studied, and observation periods, heterogeneous failure rates have been recorded, ranging from 8% for carbon fiber posts over a seven-year observation period in a retrospective study (Ferrari *et al.*, 2007), to 12% for glass fiber posts in a two-year prospective investigation (Naumann *et al.*, 2005a). *In vivo* trials have pointed out that several baseline factors—such as tooth type, position, and function in the dental arch (Naumann *et al.*, 2005a,b), existence of proximal contacts (Caplan *et al.*, 2002), and type of final restoration (Aquilino and Caplan, 2002)—may have an influence on the survival of restored pulpless teeth. Additionally, several studies have indicated the degree of hard tissue loss at the coronal level as a relevant factor for the clinical success of endodontically treated teeth (Naumann *et al.*, 2005a,b), and have highlighted the importance of preserving a circumferential dentin collar of at least 2 mm in height, the so-called "ferrule effect", for improved load-bearing ability of the restored tooth (Stankiewicz and Wilson, 2002; Zhi-Yue and Yu-Xing, 2003; Akkayan, 2004; Tan *et al.*, 2005; Pereira *et al.*, 2006).

However, no clinical study has so far specifically addressed whether and to what extent the degree of coronal tissue loss and the placement of an endocanalar post have an influence on the clinical behavior of endodontically compromised teeth.

Therefore, the present study was aimed at prospectively evaluating the two-year clinical service of root-treated premolars, with various degrees of coronal tissue loss, that were restored either with or without a post and covered with a crown. The tested null hypothesis was that neither the amount of residual coronal dentin nor the placement of an endocanalar post significantly affects the two-year survival of endodontically treated and crowned premolars.

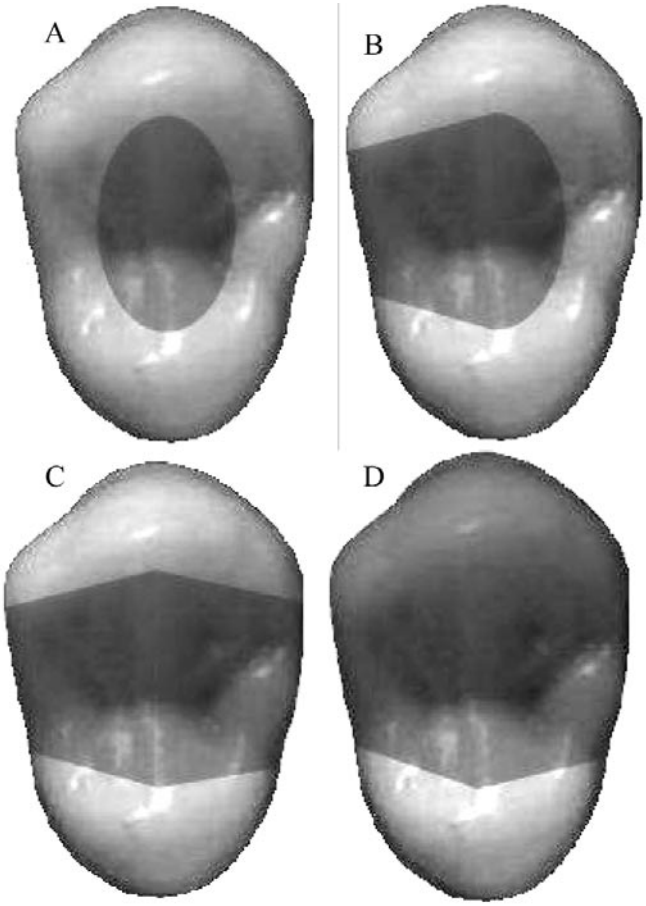

Figure 1. Schematic representations of the various degrees of hard-tissue loss that the tested premolars might exhibit at completion of endodontic treatment. The darker area represents the missing structure in the conditions referred to as **(A)** 4 coronal walls retained (Group 1, N = 40), **(B)** 3 walls remaining (Group 2, N = 40), **(C)** 2 walls maintained (Group 3, N = 40), and **(D)** only 1 coronal wall preserved (Group 4, N = 40).

MATERIALS & METHODS

A total of 210 individuals, 93 males and 117 females, who consecutively presented at a private dental office for receiving endodontic treatment and restoration of premolars, provided six experimental groups of 40 teeth each. No more than 2 teeth for each person were considered for the study. Informed written consent was obtained from the individuals after they had received a clear explanation of the purpose of the trial, according to a protocol preliminarily reviewed and approved by the Institutional Review Board of the University of Siena, Italy. Individuals' ages ranged from 18 to 76 yrs, with an average of 54 yrs. In total, 240 premolars, 128 maxillary and 112 mandibular, with various degrees of hard tissue loss, were included in the study. The selected teeth needed to be in occlusal function with a natural tooth, and in interproximal contact with 2 adjacent natural teeth. If the teeth had already been endodontically treated, the inclusion criteria (symptom-free root canal filling and a minimum apical seal of 4 mm, without any periapical lesion on the x-ray) had to be met. All the clinical procedures were performed by the same operator. Six experimental groups were defined as follows, based on the amount of dentin left at the coronal level after endodontic treatment and before abutment build-up:

(1) All the coronal walls were left intact (Fig. 1a).
(2) Three coronal walls were preserved (Fig. 1b).
(3) Two coronal walls were maintained (Fig. 1c).
(4) Only one coronal wall was present (Fig. 1d).
(5) Ferrule effect: No coronal wall was retained, although a collar of dentin at least 2 mm in height, as measured with a periodontal probe, was preserved circumferentially.
(6) No ferrule effect: No coronal wall was retained, and less than 2 mm of dentin was present circumferentially.

Within each group, in half of the teeth (n = 20), a fiber post was inserted inside the root canal to provide retention for the coronal restoration (Subgroup A), whereas in the remaining half of the premolars, no endocanalar post was placed (Subgroup B). The assignment of the teeth to either subgroup was decided by a coin toss. In the premolars with 2 roots, only 1 post was placed. For all teeth, the final restoration was a single-unit metal-ceramic crown.

Clinical Procedures

The procedure followed for root canal preparation and filling is reported in detail in Table 1.

In the teeth to be restored with a post (Subgroup A), at least 24 hrs after endodontic treatment, the gutta-percha was removed with Gates Glidden drills (Dentsply Maillefer) for a length of 7-8 mm, leaving at least 4 mm of intact apical seal.

We used DT Light Post posts (RTD, St. Egrève, France), choosing the post size (1, 2, or 3) that best fit the post space. The post was tried-in and consequently shortened with a diamond bur. The Prime&Bond NT Dual Cure adhesive system was used (Dentsply, Konstanz, Germany), in combination with the dual-cure resin cement Calibra (Dentsply). The post cementation procedure was performed according to the manufacturer's instructions (Table 1).

The abutment portion was built up with XFlow flowable composite and CeramX microhybrid composite (Dentsply). The crown preparation varied from a full chamfer with a bevel interproximally and lingually, to a feather finish, depending on height and thickness of the remaining dentin. Single-unit porcelain-fused-to-metal crowns were fabricated.

Evaluation Parameters

At the recalls after 1, 6, 12, and 24 mos, all the individuals were evaluated. The rate of success was assessed by clinical and intra-oral radiographic examinations. Radiographs were taken by the modified parallel technique and with Ultra-Speed periapical films (Eastman Kodak Company, Rochester, NY, USA), and examined at a 5x magnification. The following events were considered as failures: post debonding, post fracture, vertical or horizontal root fracture, failure of the core portion requiring a new coronal restoration, displacement of the crown, and endodontic and periradicular conditions requiring endodontic re-treatment. Evaluation of success or failure was independently performed by two examiners other than the operator.

Statistical Analysis

For descriptive purposes, Kaplan-Meier plots were constructed by subgroup (Fig. 2A), and by subgroup within each group (Figs. 2B-2F).

We applied the Cox regression analysis to assess the influence on failure rate of the presence or absence of an endocanalar post,

as well as of the amount of residual coronal dentin. The level of significance was set at $p < 0.05$.

RESULTS

Data were not affected by any loss to follow-up. The overall two-year survival rate of crowned endodontically treated premolars was 81.3%. For posted teeth (Subgroup A), the two-year survival rate was higher (92.5%) than for teeth restored without a post (Subgroup B, 70%, Table 2). In the presence of a post, no root fracture or failure of the abutment portion was recorded; all the failure events were due to post debonding, and occurred in teeth that presented with a reduced amount of residual dentin, with one wall (at most) left at the coronal level. In 2 of the post debonding cases, failure of the endodontic treatment was also observed. For the sample teeth restored without a post, 9 root fractures and 27 crown displacements were observed. The majority of crown dislodgements and all the root fractures occurred in teeth where the remaining coronal structure before abutment build-up was reduced to one residual wall at the most. All the teeth that exhibited 4 walls at the end of endodontic treatment survived the 2 yrs of clinical service, regardless of the restorative procedure including or omitting the placement of a post (Table 2).

Table 1. Clinical Procedure Followed in Root Canal Treatment, Post Space Preparation, Post Luting

Root Canal Preparation	Root Canal Filling
• Instrument the root canals with K-files (#08-10-15; Dentsply Maillefer, Ballaigues, Switzerland) and Flexmaster (#15-20-25-30-35-40 VDW, Munich, Germany), mounted on an electric handpiece (Endo IT professional, Aseptico Inc., Woodinville, WA, USA), having established the working length at 1 mm above the radiographic apex. • Between instrumentations, irrigate with 3 mL of 5.25% sodium hypochlorite, using a long 27-gauge needle. • Use de-ionized water as the final rinse, and maintain patency of the canal with a #10 K-file.	• Dry the canal with multiple paper points. • Condense the gutta-percha using the continuous wave technique up to 4 to 5 mm from the apex with a System B heat source (SybronEndo, Orange, CA, USA). • Use thermoplastic gutta-percha and an Obtura II unit (Obtura Corp., Fenton, MO, USA) at 185°C for backfilling of the canals. • Fill the root canal access with a glass-ionomer filling material (Fuji IX, GC Co., Tokyo, Japan).

Subgroup A: Post Space Preparation

Etching	Bonding	Post Luting
• Apply Caulk 34% Tooth Conditioner Gel to the post space. • After 15 sec, rinse with water. • Remove the excess water with an air blast. • With paper points, remove the residual moisture without desiccating the etched dentin surface.	• Mix 1 or 2 drops of Prime&Bond NT adhesive with the same amount of Self-Cure Activator for 1-2 sec with a clean brush tip. • Apply the adhesive/activator solution to the post space with a microbrush. • After 20 sec, remove the excess solution from the post space with an air blast and paper points. • Coat the post surface with a layer of adhesive/activator solution and gently air-dry for 5 sec. If the post surface does not appear uniformly shiny, apply a second layer and gently air-dry again.	• Mix equal amounts of Calibra base and catalyst. • Apply the mixture onto the post surface with a spatula and into the post space with a lentulo spiral. • Seat the post and remove the excess cement. • Light-cure through the post for 10 sec with a high-power LED curing light, *e.g.*, SmartLite PS (Dentsply Caulk, 950 mW/cm^2).

For all of the Subgroup A premolars that experienced post debonding, the post was luted again, and the teeth were maintained in clinical service. As for the cases of failed endodontic treatment, all the teeth presented with asymptomatic periapical lesions. Endodontic re-treatment was performed, and the teeth were restored to clinical service. All the root fractures except one were fatal failures. Thus, in one single case, through a periodontal surgery intervention (crown lengthening), fiber post insertion, and placement of a new crown, it was possible to restore the tooth to function. Conversely, all the other fractured roots had to be extracted.

The Cox regression analysis was restricted to Groups 2-6, excluding teeth presenting with 4 intact walls, that all survived regardless of the restorative procedure. The model showed that the presence of an endocanalar post was a significant factor for failure-free time. In particular, teeth restored without a post were more likely to have a shorter time to failure (hazard ratio, HR = 4.9; 95% CI for HR = 2.4 to 10.3; $p < 0.001$). Also, the amount of residual coronal dentin appeared to influence survival significantly. Specifically, failure risk was increased for teeth under the "no ferrule" (HR = 12.3; 95% CI for HR = 2.8 to 53.7; $p = 0.001$) and the "ferrule effect" conditions (HR = 8.6; 95% CI for HR = 1.9 to 38; $p = 0.004$). 'Post by dentin amount' interactions were not significant ($p = 0.9$).

DISCUSSION

The design of this study was specifically meant to assess whether the degree of coronal tissue loss and the placement of

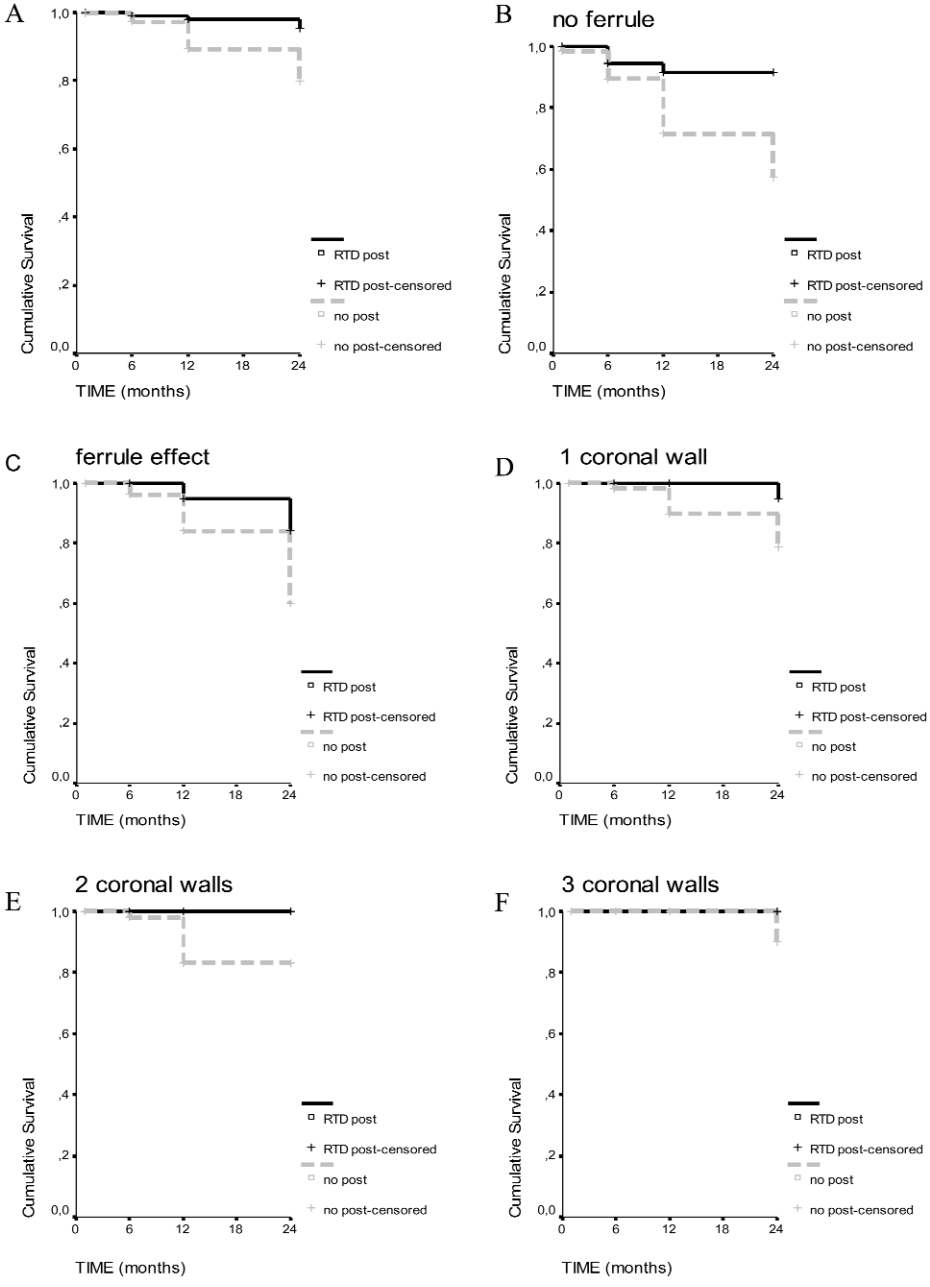

Figure 2. Kaplan-Meier plots by subgroup **(A)** showed that the survival probability was higher for posted restorations from the six-month recall on. The gap between the two curves became greater as time progressed. Kaplan-Meier plots constructed for the groups defined as 4, 3, 2, and 1 preserved coronal wall (**B-F**, respectively, N at baseline = 40 in each group) indicated that the probability of tooth failure was higher in the presence of a reduced portion of crown dentin. Also, post placement appeared to contribute more to survival probability the less the coronal structure was retained, since the gap between the "post" and "no post" plots increased as the degree of hard-tissue loss increased.

an endocanalar post have an influence on tooth survival by standardizing, as much as possible, other variables that may affect clinical service, such as tooth type and function within the dental arch (only premolars with natural teeth as neighboring and antagonist elements), as well as type of final restoration (single-unit crowns).

The first relevant finding of the investigation was that, over a two-year observation period, post placement resulted in a lower risk of failure. In particular, fiber posts appeared to contribute a protective role against what could be considered the most serious type of failure for tooth prognosis, *i.e.*, root fracture. No posted root experienced such a breakdown. Conversely, in agreement with previous clinical reports (Monticelli *et al.*, 2003), in the present trial, loss of retention was the most frequent unfavorable event for post-retained restorations. This finding upholds the idea that a reliable bonding to root canal dentin is not easily achieved (Pirani *et al.*, 2005), to the point that even the contribution of friction developed by the cement-coated post along root walls should be treasured for the sake of post retention (Goracci *et al.*, 2005; Cury *et al.*, 2006). The establishment of a valid micromechanical intraradicular bond is indeed challenged by several factors, among which the most adverse seems to be resin shrinkage stress in the unfavorable geometric configuration of the dowel space (Tay *et al.*, 2005). In contrast to the present investigation, a previous study on the survival of post restorations reported that the most frequent mode of failure was post fracture. The overall failure rate was also higher (Naumann *et al.*, 2005a). However, it could be argued that the posts tested in the cited trial had been proven to have a less satisfactory fatigue resistance than the RTD post used in our investigation (Grandini *et al.*, 2005). In a previous two-year clinical trial on root-treated premolars retaining 2 coronal walls (Monticelli *et al.*, 2003), this system had scored a 7.7% failure rate, similar to that of the present study (7.5% for Subgroup A).

With regard to the role of residual coronal dentin in restored tooth survival, several studies have suggested this role to be determinant (Stankiewicz and Wilson, 2002; Zhi-Yue and Yu-Xing, 2003; Akkayan, 2004; Naumann *et al.*, 2005a,b; Tan *et al.*, 2005; Pereira *et al.*, 2006). In agreement with these findings, all post decementations in our study also occurred in teeth retaining only 1 coronal wall, the sole ferrule, or even in teeth deprived of the ferrule effect. The same could be said about fractures occurring in non-posted roots. The statistical analysis revealed that the conditions defined as "no ferrule" and "the ferrule effect" were associated with a significantly higher risk for failure. Also, Kaplan-Meier plots

Table 2. Frequencies, Percentages, and Modes of the Failures That Occurred over the 2-year Follow-up

Residual Coronal Dentin	Post (Subgroup A)	No Post (Subgroup B)	Total (*per* Group)
(Group 1) 4 coronal walls	0/20	0/20	0/40
(Group 2) 3 coronal walls	0/20	2/20 (10%)	
	2 crown dislodgements	2/40 (5%)	
(Group 3) 2 coronal walls	0/20	6/20 (30%)	6/40 (15%)
		6 crown dislodgements (1 in combination with failure of endodontic treatment)	
(Group 4) 1 coronal wall	1/20 (5%) post debonding	6/20 (30%)	
		4 crown dislodgements (1 in combination with failure of endodontic treatment), 2 root fractures	7/40 (17.5%)
(Group 5) Ferrule effect	4/20 (20%)		
	4 post debondings (1 in combination with failure of endodontic treatment)	10/20 (50%)	
		7 crown dislodgements (2 in combination with failure of endodontic treatment), 3 root fractures	14/40 (35%)
(Group 6) No ferrule	4/20 (20%)		
	4 post debondings (1 in combination with failure of endodontic treatment)	12/20 (60%)	
		8 crown dislodgements (2 in combination with failure of endodontic treatment), 4 root fractures	16/40 (40%)
Total (*per* Subgroup)	9/120 (7.5%)	36/120 (30%)	Grand Total, 45/240 [(18.7%)]

suggested a trend for post placement to favor tooth survival the less the coronal dentin was retained. Nevertheless, between-factor interactions were not significant according to the statistical analysis. The lack of statistical significance may be related to the fairly low overall failure rate over a relatively short follow-up period. In this regard, it should be mentioned that this study's groups are still under observation, with the aim of collecting longer-term survival data. Also, it would be of interest to extend the investigation to other teeth, such as molars and anteriors, which were excluded from this trial for the purpose of standardization.

Finally, with regard to failures of endodontic treatment, since they were all concomitant with failures of the restorative procedure, whether post decementations or crown dislodgements, it can be speculated that they were caused by re-infection of the root canal following the loss of coronal seal, as already demonstrated in previous clinical investigations (Ray and Trope, 1995; Tronstad *et al.*, 2000).

In conclusion, over a two-year observation period, post placement resulted in a significant reduction of failure risk for endodontically treated premolars. With regard to the influence of residual coronal dentin, failure risk was significantly higher for teeth that had lost all coronal walls.

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