

Effect of the ferrule on fracture resistance of teeth restored with prefabricated posts and composite cores

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ABSTRACT

Background: The ferrule effect in root treated teeth requiring cast posts and cores has been shown to greatly improve fracture resistance. Studies have also shown that in the case of a cast post and core, the longer the ferrule, the greater the fracture resistance. However few studies have considered the effect of different ferrule designs on prefabricated post and composite core systems.

Aim: This study investigated the effect of different ferrule designs on the fracture resistance of teeth incorporating prefabricated posts and composite cores. It also assessed the necessity of a post in the restoration of endodontically treated teeth.

Methodology: Sixty-two extracted maxillary incisors (centrals and laterals) and canines were randomly assigned into three groups and restored. Two groups had a prefabricated post and composite core with varying ferrule designs. A third group had a core with composite packed into the root canal but no post. An Instron universal testing machine was used to apply compressive loads until failure occurred.

Results: There was no significant difference amongst the three groups as regards fracture resistance. The two groups with prefabricated posts and composite core required a mean force of 931N, std±283 and 931N, Std±242 to fracture. The third with no post group required a mean force of 1036N, std±269 to fracture.

Conclusion: In the restoration of an anterior endodontically treated tooth with a prefabricated post and composite core and where there is at least 2 mm or more of remaining coronal dentine, a ferrule may not be necessary.

Key Words: Endodontically treated teeth, Fracture resistance, Preformed Post, Composite core, Ferrule design, Ferrule effect, Ferrule length, Shoulder, Bevel, Contra-bevel.

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INTRODUCTION

The use of prefabricated posts with amalgam, composite resin or reinforced glass ionomer core build-ups has become very popular¹. In-vitro, and clinical studies have shown that prefabricated post systems perform as well as or even better than the cast post and core^{2,3,4}. Factors that may affect these restorations include crown design⁵. Crowns have been shown to alter the distribution of forces to the roots and provide a bracing or casing action to the tooth referred to as the ferrule⁶.

A ferrule has been defined as a metal ring or cap intended for strengthening the end of a stick or tube⁷. Sorensen and Engelman⁸ suggested that this "ferrule effect" be defined by a 360-degree metal crown collar surrounding parallel walls of dentine and extending coronal to the shoulder of the preparation. Libman and Nicholls⁹ defined it as a metal band or ring used to fit the root or crown of a tooth.

The ferrule or encircling band of cast metal around the coronal surface has been suggested to reinforce the coronal aspect of the dowel preparation and acts as an antirotatory device⁶. It has also been shown to greatly improve fracture resistance^{10, 9, 11, 12, 13}. Loney¹⁴ found that the collar had a significant effect on stress distribution. He suggested that the ferrule may help to unite different portions of the tooth. It has also been suggested to act as an antirotatory device⁶, and to maintain the cement seal.

Libman & Nicholls⁹ suggested that to achieve the full benefits of the ferrule effect it should be a minimum of 1.5 mm in height and have parallel dentine walls, totally encircle the tooth, end on sound tooth structure and avoid invasion of the attachment apparatus of the tooth.

Most of the studies investigating the ferrule effect have used cast posts and cores, few studies have considered a ferrule effect or design on prefabricated posts and composite core systems^{15, 4, 16}.

The aim of this study was to investigate the effects of different ferrule designs on the fracture resistance of teeth incorporating prefabricated posts and composite cores. In addition the teeth were also compared to teeth having a composite core without any post.

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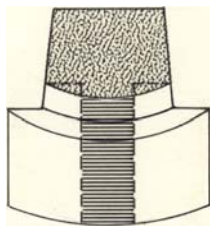
MATERIALS AND METHODS

Sixty-two extracted maxillary incisors (centrals & laterals) and canines were collected. The teeth were visibly inspected and only those with minimal caries were included in the study. Teeth with fractures or cracks were excluded. The teeth were stored in a thymol solution at room temperature to prevent bacterial growth.

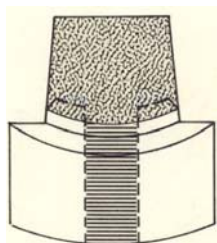
The endodontic treatment was completed for all the teeth using the standardised technique¹⁷. Each tooth was instrumented according to clinical guidelines in relation to its size, using reamers and K files. During instrumentation, copious irrigation was performed with saline. The canals were dried with air and absorbent paper points. They were obturated using gutta percha points by lateral condensation with the aid of a finger spreader. Tubliseal (De Trey/ Dentsply) was used as the cement for obturation with gutta percha. The teeth were decoronated 2mm (proximal surface) above the cemento-enamel junction perpendicular to their long axis using a model trimmer with a continuous water coolant.

All teeth had a crown preparation with a 90° shoulder 0.5mm in width following the cemento-enamel junction. The shoulder margin was prepared using a conventional high-speed handpiece with a flat-ended fissure diamond bur. The teeth were distributed into three groups (figures 1, 2, & 3)

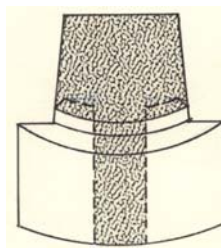
(Figure 1) Group 1, had twenty-two decoronated teeth with prefabricated posts with a butt joint configuration at the tooth core junction.



(Figure 2) Group 2, had twenty decoronated teeth with prefabricated posts with a 1 mm wide contra bevel at the tooth-core junction



(Figure 3) Group 3, had twenty decoronated teeth with no posts with a 1 mm wide contra bevel at the tooth core junction. The composite extended 4 mm inside the root canal instead of a post



(Diagrams adapted[®])

Using a Gates Glidden bur, the gutta percha was removed from groups 1 and 2 leaving at least 4-5mm to create an apical seal. Teeth in group 3 had only 4mm of gutta percha removed from the coronal part of the canal. The ferrule in the case of groups 2 and 3 was prepared by making a 1mm wide contra bevel at the root-core junction using a conventional hand-piece with a chamfer diamond bur.

Post spaces were prepared for groups 1 & 2 using the para post system (Coltene/ Whaledent Inc, USA). The posts were cemented using Dyract Cem (Caulk/ Dentsply) a dual-cure acid resin modified cement. All the cores were prepared by free hand to a 7mm height using a composite resin (TPH, Dentsply/ L.D. Caulk). All posts were completely covered by the composite. Metal copings of 0.5 mm thickness and 8mm height were fabricated in the laboratory and used to simulate final restoration. They were luted onto the teeth using Dyract Cem (Caulk/ Dentsply). The teeth were embedded in autopolymerising acrylic resin blocks upto 2 mm below the cemento-enamel junction. The Zwick testing instrument (Zwick GmbH and Co., postf. 4350, D-7900u/m, Germany) was used to apply compressive loads progressively on the restored teeth until failure occurred. The load was applied at an angle of 135 degrees to the long axis of the tooth. This angle simulates the average angle of occlusion between maxillary and mandibular incisors in a class I occlusion.

RESULTS

The failure threshold was defined as the maximum load a sample could withstand until fracture. Failure loads, modes of failure, and tooth preparation (ferrule design) were recorded and statistically analysed for significant correlations between design and failure loads. The data was analysed using the SPSS system. The one-way analysis of variance (ANOVA) was used to determine whether the fracture resistance differed significantly among the three groups, and whether differences in the other variables were

significant. Results from four specimens were discarded due to errors caused by the testing machine (Zwick machine) and the laboratory technicians.

The analysis of variance (ANOVA, table II) showed that there was no significant difference amongst the three groups as regards fracture resistance, although teeth (table I) with ferrule and

no post (group 3) required a much higher mean force (1036N, std \pm 269) to fracture when compared to teeth in the other two groups. Teeth with a butt joint (group 1) required a mean force of (931N, std \pm 283) and teeth with a ferrule and a post (group 2) required a mean force of (931N, Std \pm 242) as presented in table I.

Table 1. Descriptive statistics in Newtons comparing the mean force needed to break teeth in the different groups

Group	Mean	Numbers	Std	Median
Butt joint	931.3005	22	282.83492	899.0150
Ferrule/ post	930.5489	18	241.90164	899.8800
Ferrule no post	1035.7461	18	268.76516	1075.3200
All teeth	963.4814	58	266.19414	909.4050

DISCUSSION

Thymol solution has been used by many researchers¹⁶ as a storage agent because of its antifungal activity. It was used in this study because the teeth had to be stored for an extended period as collection of the specimens proceeded.

The Parapost system was used because it has a long record of clinical success³ and has been known to represent the industry standard for prefabricated posts. It satisfies the general criteria of a good post system being parallel, serrated and vented¹⁸.

Acid modified resin cement (Dyract cem) was used in this study because it has been found to enhance the retention of the parallel-sided posts and increases fracture resistance¹⁹. This may be due to the dentine bonding provided by these cements.

Composite resin was chosen as the core material in this study because composite cores have been found to have a high fracture resistance^{20, 21}.

Aquaviva⁵ suggested that laboratory studies must have some degree of clinical correlation in order to be practically applicable. Therefore the teeth in this study were restored with laboratory made crowns so as to simulate the clinical situation as far as possible.

The coronal dentine extension used for all the groups was 2mm because it has been recommended as the minimum length, which can compensate for the difficulties of intraoral tooth preparations²².

Posts in some parts of the mouth are subjected to rotational forces. Anti rotational features are placed to counteract these forces. These features can be placed in tooth roots by slotting the most coronal

internal position of the post channel or by placing pot-hole channels or retentive pins in the dentine mesially and distally to the post channel. The most important anti rotatory feature for posts and cores is the placement of a ferrule effect¹¹ circumferentially around the build-up and remaining root stump by extending the crown preparation margins at least 1-2 mm apically to the composite tooth structure interface.

In-vitro studies have shown that the ferrule effect significantly reduces the incidence of fracture in non-vital teeth by reinforcing the tooth at its external surface and redistributing applied forces¹⁴. However, this study showed no significant difference in the forces needed to break teeth with or without the ferrule (table I). This finding is in agreement with other researchers^{16, 23}.

The mean failure load values of this study and of the two studies mentioned above were high compared to findings by previous studies; Volwiler¹⁵ 21.6 kg (212 N), and Sorensen and Engelman⁸ 65.3 kg (640 N).

The high forces in this study are probably due to the use of the duo cured resin modified cement (Dyract cem, Dentsply) and the cements ability to chemically bond to the dentine and micro-mechanically bond to the post.

The results further showed no statistically significant (table II) difference regarding the amount of force needed to fracture teeth with and without posts in this study. These findings are related to another study³ in which a retrospective study was carried out and found that there was no significant increase in fracture resistance gained with intracoronal reinforcement. However, in this study teeth without posts required (1036 N) a higher amount of force to fracture than the teeth that had posts (931 N). This suggests that the use of posts should be avoided when they are not required to provide retention for the core.

Table II. ANOVA tables for the force needed to break teeth between the different groups

	Sum of squares	df	Mean square
Between-groups (Combined)	136304.79	2	68152.395
Within groups	3902676.4	55	70957.753
Total	4038981.2	57	

	F	Sig
Between groups (Combined)		
Within groups		
Total	0.960	0.389

The relatively lower values (table I) required to break teeth restored with posts in this study were probably due to weakening of the tooth structure during post channel preparation. Therefore when insufficient tooth structure exists to prepare for coronal coverage, a composite resin coronal-radicular core may be appropriate as a post and core build-up in the restoration of anterior teeth, if there is sufficient dentinal wall to act as a ferrule.

However when evaluating the results of this investigation, it should be noted that there may be limitations to the direct application of in-vitro results to clinical situations. Some of the limitations encountered included; variations among the specimens within the groups, which is inherent with these types of studies because of the natural variation among the teeth that are used. Lack of a periodontal ligament such that the teeth were embedded in acrylic resin, which showed resilience. The number of teeth used in this study were limited such that no conclusions could be drawn from some variables.

CONCLUSIONS

The two major conclusions from this study are;

1. In the restoration of an anterior endodontically treated tooth having at least 2mm or more of remaining coronal dentine, a ferrule effect provides no statistically significant improvement when a prefabricated post and composite core is used.
2. In the restoration of an anterior endodontically treated tooth with at least 2mm or more of remaining coronal dentine, a post provides no statistically significant improvement in fracture resistance compared to a similar tooth being restored with a radicular extension of 4mm of the composite core and no post.

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