ORIGINAL RESEARCH ARTICLE

COMPARATIVE ANALYSIS OF COMPRESSIVE RESISTANCE OF THREE DIFFERENT POST AND CORE SYSTEMS

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ABSTRACT

Aims & Objectives: The purpose of this study was to determine and compare the fracture resistances of 3 post-and-core systems with a cast metal post and core using a clinically related test method.

Material and Methods: 80 recently extracted caries-free maxillary central incisors assigned to 4 experimental groups (n=20). The cast metal (Wiron 99) post-and-core group served as the control. Three experimental groups consisted of GC Fiber post core Group (GC America) (Group A), Luxa post (DMG America LLC) core group (Group B), and Rely-X fiber post (3M ESPE) core group (Group C). The post spaces were prepared, posts were seated, cores were formed, and 80 post-and-core foundations were cemented into the roots. Following thermal cycling, a compressive load was applied to the inclined surface of each specimen until failure occurred. Force to failure (N) was recorded. Data were analysed with a 1-way analysis of variance and Post Hoc Bonferroni tests to determine the difference between the groups.

Results: Groups CP (679.4 N) and B exhibited the highest resistance to fracture. The Group A showed the lowest fracture resistance (487.2 N). The fracture resistance of the C group (565 N 6 7.2) was lower than the CP and B groups, and higher than the A group. The differences among the groups were significant (P<.001)

Conclusion: Within the limitations of this study, the cast metal post/core and zirconia post/ composite-resin core foundations were found to be more fracture resistant than the fiber post/composite resin core foundations.

Key Words: Post and core foundations, coronal fractures, cast post and core, fiber post, zirconia-post.

INTRODUCTION

Anterior teeth with coronal fractures and discolorations are often endodontically treated and restored with complete crowns. However, these teeth are weaker and more brittle because of desiccation or loss of moisture supplied by a vital pulp. Posts are recommended to strengthen weakened endodontically treated teeth against intraoral forces by distributing torquing forces along the roots.[1,2] A post-and-core

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system provides retention and support for the restoration of teeth lacking sufficient coronal tooth structure to support a restoration.[3]

Cast metal post-and-core foundations have been used successfully due to their superior physical properties.[4] However, esthetic properties of these materials are limit their use in the anterior region since the gray-colored post is apparent when used to support translucent all-ceramic restorations.
Also, the high elastic modulus of cast posts and cores have been reported to cause stress concentrations within the surrounding radicular dentin, giving way to root fractures.[5,6]

It has also been tested that cast posts and cores have a tendency to cause tooth fracture, whereas composite-resin cores and metal posts are more susceptible to cause core failure.[7-12]

The increasing demand for more esthetic and biocompatible anterior restorations has led to the development of tooth-colored, translucent, metal-free post-and-core systems.[13-15] Prefabricated zirconia ceramic post system has been introduced to satisfy esthetic needs presented by endodontically treated anterior teeth.[16-24]

Abundant studies have been executed to determine the fracture resistance of prefabricated post systems. Dean et al[20] tested the fracture resistance of 3 different types of posts and composite-resin cores and reported that there was no significant difference among the groups tested. Heydecke et al[18] stated that zirconia posts with ceramic cores can be recommended as an alternative to cast metal posts and cores. Asmussen et al[21] studied zirconia posts and found that stiffness and resistance to fracture were similar to prefabricated titanium posts. However, the fracture resistance of teeth restored using recently introduced esthetic post-and-core systems has not been thoroughly investigated. The purpose of this in vitro study was to determine and compare the fracture resistance of 3 esthetic post-and-core systems with a cast metal post and core under compressive loading.

MATERIAL AND METHODS

Eighty recently extracted caries-free maxillary central incisor teeth were selected and stored in neutral buffered formalin solution. The coronal aspect of each tooth was resected perpendicular to the long axis and 1 mm incisal to the cementoenamel junction (CEJ) with a 45-mm-diameter diamond-coated disc (Monotrac, Salt Lake City, Utah). Labiolingual and mesiodistal measurements of the sectioned tooth surfaces were made with a metal gauge to calculate the average diameter. The roots were endodontically instrumented to the apex with the step-back technique[26] using K-type files (Dentsply Maillefer, Tulsa, Okla). Enlarged canals were irrigated with a 2.5% sodium hypochlorite solution, rinsed with saline, dried with paper points and obturated with thermoplasticized gutta percha (Dentsply, India) and a resin sealer (AH 26; Dentsply DeTrey, Konstanz, Germany). The teeth were embedded in acrylic resin blocks (DPI, India), at a level 2 mm apical to the CEJ. The teeth were then assigned to control or experimental groups(n=20).

The cast metal post-and-core (Group CP) worked as the control group and were fabricated from a nickel-chromium alloy (Wiron 99; BEGO, Bremen, Germany). The GC fiber post /composite-resin core foundations (Group A) were prepared using GC Fiber posts and composite-resin cores (Gradia-core, GC). The Luxapost zirconium filler post/composite-resin core foundations (Group B) were prepared using prefabricated zirconium filler posts (Luxapost, DMG, America) and composite-resin cores (Luxacore, DMG,America). The rely-X Fiber post/ composite core foundations (Group C) were prepared using prefabricated Rely-X fiber posts (3M, ESPE) and cores (Filtek™ Supreme XT Universal Restorative,3M, ESPE).

Specimen preparation

To obtain standardized cores, a closed-end conical hollow brass matrix (6-mm-diameter base, 5-mmdiameter closed end, and 5-mm height) was cast. The base of the brass matrix was fitted flush to the sectioned tooth surfaces. A bevel-shaped cut made at the closed end of the matrix at a 50-degree angle created an opening to the inside of the matrix, the edge of the opening representing the palate-incisal surface of an incisor tooth.

For the CP group the post spaces were enlarged with drills (Gates-Glidden, No 3 and 4; Dentsply, India). The final enlargements were accomplished with a 1.5-mm-diameter drill (ParaPost, No 4; Coltene/Whaledent) to a depth of 10 mm. The cervical apertures of the enlarged canals were filled with a heavy-bodied condensation silicone impression material (Zetaplus; Zhermack SpA, Badia Polesine, Italy). Next, heavy-bodied silicone impression material was removed from the canal apertures. A direct technique was used to make post casting patterns. The canals were lubricated with a separator (Isolant/CMS; Dentsply DeTrey) and filled with an autopolymerizing acrylic resin (Duralay; Reliance Dental Mfg, Worth, Ill) using a lentulo spiral (Dentsply Maillefer). The matrix was centered on the sectioned tooth surface using the inscribed guide line and was fixed in position. Auto-polymerizing acrylic resin was injected inside the matrix through the matrix aperture to form the core with the previously specified dimensions. A smooth glass surface was pressed over the matrix opening to displace excess acrylic resin and to shape the flat palate-incisal surface of the core. After polymerization, the brass matrix was removed from the moulded core and the acrylic resin pattern was retrieved from the root, invested, and cast with a nickel-chromium alloy (Wiron99) according to the manufacturer's recommendations. The final Cast post and cores were cemented into the roots (Zinc phosphate cement, Harvard Dental International). For the Group A,B and C post spaces were prepared as previously described for the CP group.

The fabricated posts were cemented to the specimens and then all specimens were subjected to thermal cycling for 5000 cycles between 5C and 55C, with a dwell time of 30 seconds at each temperature.[27] Loading procedure A universal testing machine (Instron 1195; Instron Corp, Canton, Mass) was used to apply compressive loads. The specimens embedded in acrylic resin blocks were fixed on the aluminum base of the testing machine at a 50-degree angle to the horizontal plane.

A constant compressive load was applied at a crosshead speed of 1 mm/min, at a 120-degree angle to the long axis of the test specimens, until failure occurred. The applied load was automatically stopped at the first instance of specimen fracture. Data were analyzed with a statistical software program (SPSS 9.0 for Windows). For the overall comparison, a 1-way analysis of variance (ANOVA) and Bonferroni tests were used to determine the difference between the groups. A 95% confidence level was used for the ANOVA test. For pairwise comparisons among group mean values, $P<.0083$ indicated statistical significance and established the overall confidence level at 95%.

RESULTS

The mean failure values, SDs, and types of fractures that occurred are presented in Table I.

Fracture resistance comparisons between the groups are listed in Table II.

The CP and C groups exhibited the highest fracture resistance values—720.8 N and 708.7 N, respectively. The B group showed the lowest resistance. The fracture resistance of group B (708.7 N) was higher than group A (475.2 N) and lower than groups CP and C. The differences between the groups were statistically significant (P,.001) (Table III).

DISCUSSION

The fracture resistance of A,B and C foundations were tested and compared with the CP group. The average failure values varied between 475.2 N and 708.7 N. The CP and B groups showed the highest resistance among groups (720.8 N and 708.7 N, respectively), whereas the A group exhibited the lowest resistance values (475.2 N).
In this study, the post-supported cores were not restored with crowns. As in similar previous studies,[7-12] the compressive load was directly applied to the inclined surfaces of the cores. In this manner, the probable altering of parameters, such as material structure, shape, length, and thickness, by crown restorations was avoided. It is considered that by eliminating such parameters, the structural integrity and fracture resistance of a post-and-core foundation could be tested more precisely.

Most studies that evaluate the load-bearing properties of various posts relied on the monotonic failure modes of post-and-core specimens made with natural teeth. The predicament in such testing is high SDs in failure data. This could be explained by the variations in mechanical and physical properties of individual teeth. Even if the teeth were dimensionally similar, the root canal and the tooth contours, as well as the dentin thickness, significantly affect the stress distribution in the remaining tissues.[5]

The replacement and reinforcement of intraradicular tooth structure with a material having an elastic modulus similar to that of dentin is better than replacing lost intraradicular tooth structure with an inflexible material. The cast metal and stainless steel posts have a high modulus of elasticity, which has the potential to transfer and concentrate the applied stresses to the surrounding compromised root structure. In contrast, the combination of prefabricated posts with core materials having a low elastic modulus distributes stresses more equally and preserves the surrounding dentin tissue.[6]

The average fracture value recorded for the A group (475.2 N) was lower than the values reported by Dean et al,[20] who found a failure value of 107 kg. This difference may be explained by the difference in crosshead speed applied. In the present study, the crosshead speed was 1 mm/min, whereas Dean et al[20] used a crosshead speed of 0.5 mm/min.

The specimens of A group displayed the least fracture resistance. This finding can be attributed to the low compressive strength values of the composite resin core. However, specimens of the B group showed a higher resistance value than A.

The shape of the root canals is also an important factor that influences the stress distribution within the structure of a restoration. Funnel-shaped canals, in contrast to post spaces with parallel walls, result in a different distribution of stress from the post-and-core foundation to the root structure due to material differences between posts and cores.[23] The differently shaped post spaces might show significantly different fracture resistance values due to the amount of post length or core material in contact with root structure.[23] The cement layer surrounding either fractured or intact posts remained attached and unbroken on post space surfaces. This may be explained by the high compressive strength of the resin luting agent and zinc phosphate cement used.[24]

CONCLUSION

This in vitro study evaluated the fracture resistance of recently introduced esthetic post-and-core systems compared with the conventional cast metal post-and core foundation. Within the limitations of this study, the following conclusions were drawn:

1. The CP and C groups were more resistant to compressive loading than the A and B groups ($P<.001$).
2. The B group was more resistant to fracture than the A group ($P<.001$), which was the least resistant of the groups tested.

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TABLES:

Table I. Mean failure values, SDs, and fracture types in tested groups

Group	Mean force (N)	SD	Root fracture	Post fracture	Core fracture
CP	720.8	9.8	18	-	-
A	475.2	4.6	12	15	9
B	708.7	5.8	9	-	2
C	579.5	7.2	7	8	7

Table II. Fracture resistance comparison between groups

Groups	Difference
CP-A	P<.001
CP-B	P<.001
CP-C	P<.007
A-B	P<.001
A-C	P<.001
B-C	P<.001

Table III. One-way ANOVA results

Source of variance	F	P
Between groups	50.72	<0.001
Within-groups		
Total		