Fracture resistance of esthetic post and core systems

Comparison of fracture resistance of three recent esthetic post and core systems with cast metal post and core to compressive loading – An in vitro Study

ABSTRACT:

Aim: To determine and compare the fracture resistance of three recently introduced esthetic post and core systems with a cast metal post and core to compressive loading using a clinically related test method.

Materials and Methods: Forty maxillary central incisors were selected, sectioned and their roots endodontically treated and assigned to 4 experimental groups (n= 10). The cast metal post and core (CMPC) served as control group. The other groups are zirconium dioxide post and ceramic core group (ZCER), zirconium dioxide posts and composite core group (ZCOM) and glass fiber post and composite core group (GFCOM). The post spaces were prepared, posts were seated and cores were formed. A compressive load was applied to the inclined surface on each specimen until failure occurred and measured in newtons.

Results: CMPC and ZCER groups exhibited the highest resistance fracture and the values are : 680. 6 N and 630. 03 N respectively . ZCOM group exhibited fracture resistance greater than GFCOM but less than ZCER and CMPC.

Conclusion: CMPC group and ZCER group were found to be more fracture resistant than the ZCOM group and GFCOM group. Aside from its desirable esthetic properties, the ZCER group demonstrated high resistance to fracture.

Keywords: compressive loading, endodontic treatment, fracture resistance, post and core

INTRODUCTION

Endodontic therapy has provided dentistry the ability to retain teeth that just a few decades ago would have been extracted without hesitation. When there is substantial loss of coronal tooth structure due to caries, trauma or both, a post and core is often required to retain a definitive restoration.

A post is usually placed in an attempt to strengthen the tooth. [1, 2, 3] However, in vitro and in vivo studies have demonstrated that a post cannot reinforce endodontically treated teeth. [4, 5, 6] Posts are required for supporting a core foundation when there is insufficient clinical crown remaining. [4, 5, 6, 7]

Although cast post and core foundations are the gold standard for endodontically treated teeth, due to their superior physical properties and proven clinical effectiveness [8] yet its mechanical properties may increase the risk of root fracture [9] . The esthetic properties of these materials are limited since the gray colored post is apparent when used to support translucent all ceramic restorations. Coupled with a high lip line, cast metal post and core foundation may create esthetic problems.

In the recent times, there has been a tremendous increase in the use of all ceramic crowns, particularly for anterior teeth because of their superior natural appearance compared to metal ceramic restorations. [10] Both the declining acceptance of cast post and core restorations as well as patients interest in dental esthetics has resulted in the development of esthetic posts, especially Glass Fiber and Zirconia Ceramics. These increase the transmission of light within the root and overlying gingival tissues, enhancing the esthetics. They also eliminate the potential hazards of corrosion and allergic hypersensitivity as they are metal free materials. [11]

Glass fibers such as silica or quartz reinforced epoxy resin posts have low modulus of elasticity similar to that of dentin. [12] This property has been reported to reduce the risk of root fracture. [13, 14] Glass fiber reinforced posts also have the advantage of easy removal if endodontic re-treatment is required. [15, 16]

A prefabricated zirconia ceramic post system has been introduced to satisfy esthetic needs presented by endodontically treated anterior teeth. The translucency of all ceramic crowns can be successfully maintained with the use of ceramic post and core materials. Moreover improvements in adhesive porcelain bonding systems have accelerated the trend toward the use of ceramic core materials. Many dentists prefer to use prefabricated post systems because they are more practical, less expensive and in some situations less invasive than customized post and core systems. They also save time and can provide satisfactory results. [17, 18, 19]

The purpose of this in vitro study is to determine and compare fracture resistance of three esthetic post and core systems, Zirconia post and Ceramic core, Zirconia post and Composite core and Glass Fiber post and Composite core with cast posts under compressive loading.

METHODOLOGY

Forty extracted human permanent central incisors were selected based on similar dimensions, caries free, no restorations and cracks. The teeth were soaked in 3% sodium hypochlorite (Vishal Dentocare PVT LTD), for 6 hours.

These forty teeth were divided into 4 groups:

Group 1: Cast Metal post and core (CMPC)

Group 2: Zirconia posts and Ceramic core (ZCER)

Group 3: Zirconia posts and Composite core (ZCOM)

Group 4: Glass Fiber posts and Composite core (GFCOM)

The coronal aspect of each tooth was resected perpendicular to the long axis and 1mm incisal to the cementoenamel junction, with a diamond coated disc (Horico) mounted in a straight handpiece (NSK, Japan). Labiolingual and mesiodistal measurements of the sectioned tooth surfaces were made with a digital vernier calipers (Aero space, China). The roots were endodontically instrumented to the apex using protaper rotary instruments (Dentsply, Maillefer) till F3 and obturated with protaper GP points (Dentsply, Maillefer) using ZOE sealer.

Procedure for fabricating standardized cores:

To obtain standardized cores, a wax pattern was fabricated from casting wax (Sk Dental waxes, Bombay) which had 6. 5mm diameter base, 7. 3 mm diameter cervico incisally and 6. 2mm buccolingually. Impression of the wax pattern was taken with rubber base impression material (Exaflex). Then dies were made from the impression material. Polyvinyl material was vacuum pressed on these dies. In this way a hollow matrix was fabricated which had the same dimensions as that of the wax pattern. The base of the matrix was fitted flush to the sectioned tooth surfaces. Then 1 mm of the matrix was cut at the open end so that it acted as an inlet for the placement of composite resin.

Procedure for preparation of forty samples: For all the groups the post spaces were enlarged with peeso reamers no 2 and 3 (MANI CE 0197 Prime Dental Products PVT LTD) initially to a depth of 9mm. The final enlargements were accomplished with the 1. 4 mm diameter drills that were specifically given with 1. 4mm zirconia posts (Cosmoposts, Ivoclar Vivadent) and 1. 4mm GF posts (Bioloren, Ammdent).

All the posts have 1. 4mm diameter and were sectioned to a standard length of 13mm using carbide fissure bur and high speed airotor handpiece The length of the posts was 4 mm from the finish line into the core. In groups 2, 3 and 4 all the post spaces were etched using 37% orthorphosphoric acid (3M ESPE), for 30 sec and bonding was done using a bonding agent (3M ESPE) polymerized for 20 sec. Cementation was done using dual curing resin luting agent (Kerr, Orange, CA).

Group 1: A direct technique was used. The post pattern was fabricated using inlay wax. For the core part , the polyvinyl matrix was placed on the tooth, resin wax (Leva) was injected in to the matrix and polymerized. After polymerization, the matrix was removed from the molded core. Then the entire pattern was retrieved from the root, invested and cast. The cast post and core systems were then cemented into the roots using GIC.

Group 2: Posts were seated into the prepared post space. Polyvinyl matrix was placed on the tooth surface, resin wax was then injected in to the matrix and polymerized for 20 sec to form the core. Matrix was then removed and retrieved post and core foundations from the roots were invested with a phosphate bonded investment (Deguvest). Wax was eliminated from the invested units in a pre heated furnace (Unident) (800ËšC for 45 minutes). Cores around zirconia posts were prepared using ceramic ingots (e-max, Ivoclar vivadent) heat-pressing process (975ËšC for 45 min.) in a heat pressing furnace (Ivoclar vivadent). The formed ZCER foundations were then cemented into the post spaces.

Group 3: After etching and bonding, posts were cemented in to the prepared post spaces. The matrix was seated on the sectioned tooth surface and composite core material (Z350, 3M ESPE) was placed in 2mm increments and polymerized for 20 sec. After polymerization, the matrix was removed from the molded cores.

Group 4: Following etching and bonding posts were cemented into the prepared post spaces. The matrix was placed on the sectioned tooth surface and composite was placed in 2mm increments and was then polymerized for

20 sec. After polymerization, the matrix was removed from the molded cores.

LOADING PROCEDURE:

Following thermal cycling (5000 cycles between 5ËšC and 55Ëš C with a dwell time of 30 second) a universal testing machine (Shimadzu, Japan) was used to apply a constant compressive load at a crosshead speed of 1mm/min, at a 130º angle to the long axes of the test specimens, until failure ocurred. The tip of the loading bar was positioned to contact the centre of the palatoincisal surface at an angle of 90ºC. The force at failure was measured in newtons.

RESULTS

One-way Analysis of Variance (ANOVA) with Post HocTukey test was used to compare the score between the groups. A 95% confidence level was used for the ANOVA test. Results showed that there was significant difference in the fracture resistance values obtained with different groups (p <0. 05).

Graph 1 represents the mean values obtained by calculating the fracture resistance values of the four post and core systems after compressive loading and the values are 680. 0673, 630. 0389, 448. 2185 and 381. 7715 respectively. CMPC and ZCER groups exhibited the highest resistance fracture and the values are: 680. 6 N and 630. 03 N respectively . ZCOM exhibited fracture resistance greater than GFCOM but less than ZCER and CMPC. GFCOM group showed the least resistance to fracture to compressive loading.

CMPC group exhibited 7 root fractures out of 10 specimens. There was also post dislodgement in 5 specimens. In ZCER group there were 4 root fractures, 3 post fractures and 5 core fractures. In ZCOM group there was no root fractures but 3 post fractures and 5 core fractures. In GFCOM group no root fracture was seen but there were 5 post fractures and 6 core fractures.

GRAPH 1: Graph 1 represents the mean values obtained by calculating the fracture resistance values of the four post and core systems after compressive loading.

DISCUSSION

Endodontically treated teeth often lack coronal tooth structure as a result of caries, previous restorations, trauma or endodontic procedures. The quantity of coronal and root dentin that remains after root canal treatment and post space preparation plays an important role in prolonging the life of the tooth and restoration. [20] This present study attempted to test fracture resistance of three new esthetic post and core systems to compressive loading.

In this study the highest fracture resistance was displayed by CMPC group. This finding is in agreement with an invitro study that determined and compared the fracture resistances of 3 recently introduced esthetic post-and-core systems with a cast metal post and core using a clinically related test method. [21] Though CMPC group exhibited the highest resistance to fracture, with esthetic dentistry gaining importance day by day, there is declining acceptance of cast post and core system. Spear F. in 1999, Turner CH in 1982, Soresen JA, Martionoff JT in 1984 have demonstrated that the most common cause of failure for cast posts and cores is post dislodgment, followed by root or post fractures. In the present study all the teeth restored with cast post and core systems showed root fractures as well as post dislodgement after testing. Recent studies suggest that the elastic modulus of the posts should be similar to that of root dentin to reduce the risk of root fracture · [22] . Metal posts have a high modulus of elasticity, i. e., they have up to 20 times the value for dentin which is approximately 18 GPA, which causes force concentration in areas where the dentin wall is thin, which may increase the incidence of root fractures. [23, 24]

Restoration of endodontically treated teeth with metal free physiochemical homogenous materials that have physical properties similar to those of dentin has become a major objective in dentistry. Zirconia ceramics offers superior strength when compared to other post materials. [25] They exhibit high flexural strength and fracture toughness. The use of a composite as a core material has also enhanced the ability to reproduce the shade and translucency of natural teeth. FaTaner Dilmener, Cumhur Sipahi, and Mehmet Dalkiz in 2006 [21] and Guido Heydecke, Fran Butz, Amr Hussein and Jorg R. Strub in 2002 [26] have suggested that zirconia posts with ceramic cores can be recommended as an alternative to cast posts and cores. If a chariside procedure is preferred, zirconia posts with composite cores can be used. When a zirconia post is used with a direct composite core, a large stress bearing composite core should be avoided. Zirconia posts with heat pressed ceramic cores have been suggested for use because their similar thermal expansion coefficients may result in favourable shrinkage and fit of the restoration. Zirconia has a high modulus of elasticity, due to which forces are transmitted directly to the post/tooth interface without stress absorption . This may be the reason due to which some of the posts fractured in the present study.

In the present study ZCOM group displayed less resistance to fracture when compared to ZCER group and CMPC group, but more than GFCOM group. This can be attributed to the low strength of the composite material itself and less adhesion between the Zirconia and composite core. To enhance the bond between the post heads and tne cores, adhesive resin luting agents can be applied to the post prior to forming the core.

Arsif D, Oren E, Marshal BL, Aviv I in 1989, Deutsch As, Musikant BL, Cavallari J , Lephy JB, in 1983 and kantos ME, Pines MS in 1977 have reported that the biomechanical properties of fiber reinforced resin composite posts are similar to those of dentin due to which they are capable of creating homogenous stress distribution, increased resistance of the tooth to fracture and decreased catastrophic root fracture. Goldberg and Burstone reported that glass fiber reinforced post systems were composed of unidirectional glass fibers in the resin matrix that strengthened the structure of post without compromising the modulus of elasticity. [27] This low elastic modulus of GFCOM system follow the natural flexural movements of the tooth, reducing stress arising at the interfaces, enabling the restored system to mimic the mechanical behaviour of a natural tooth. In the present study teeth restored with GFCOM systems did not show any root fractures but had core or post fractures. Fractures obtained with fiber posts are reparable. [28] Use of resin luting cements for luting the post will improve adhesion of post material to the tooth. This will not only strengthen the root but also will improve fracture resistance of the tooth to masticatory forces. Application of adhesion of resin luting agent on to dowel head causes significant strengthening on the dowel head retention of the core materials. [29] Different surface treatments of prefabricated esthetic posts such aetching by hydrofluoric acid and sandblasting or airblasting with Al2O3 increase retentive strength of posts. 30

This present study demonstrated that the CMPC group exhibited high fracture resistance compared to other groups, but at the same time more incidences of root fractures was noted which could cause an irreversible damage to the tooth and necessitate extraction. ZCER group have shown incidence of root fractures, less than CMPC group but more than ZCOM group and GFCOM group with excellent aesthetics and leaves dentist with a scope of retreatment in case of post and core failure. ZCOM group and GFCOM exhibited fewer incidences of root fractures, though there was an incidence of post and core fractures, the failures were not irreversible.

CONCLUSION:

The CMPC group and ZCER group were found to be more fracture resistant than the ZCOM group and GFCOM group. ZCOM exhibited fracture resistance greater than GFCOM but less than ZCER and CMPC. GFCOM group showed the least resistance to fracture to compressive loading. Aside from its desirable esthetic properties, the ZCER group demonstrated high resistance to fracture.

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