Comparative evaluation of fracture resistance of self-adapting PFS and elastic FRC post and core systems – An *in vitro* study

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INFORMATION

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ABSTRACT

Background: Endodontically treated teeth (ETT) with extensive coronal destruction are more prone to fracture, so restoring these teeth with techniques that will not compromise the integrity of remaining tooth structure with the use of Post and core systems to retain full and final crown restorations seems mandatory. Anatomic posts have been introduced which have better adaptability to the canal anatomy and conserve more amount of tooth structure. **Aim:** This study was done to compare the fracture resistance of ETT restored with two anatomic post systems elastic FRC post (everStick) and self-adapting PFS (Spirapost). **Materials and Methods:** Twenty single rooted maxillary central incisors were selected for the study. All the samples were endodontically treated and randomly divided into 2 groups (n=10) according to the post system used (PFS post – Group I, FRC– Group II). In all the samples, post space preparation was done and the posts were luted using dual cure resin cement (Para core, Coltene, Mumbai, India). The remaining core was built using composite resin (Filtek, 3M, ESPE, USA). The samples were stored in saline for one week. All the samples were thermocycled for 500 cycles from 5 to 55^{0}C ±5^{0}C with a dwelling time of 30 seconds in each bath and a transfer time of five seconds. Fracture resistance of the samples was measured using universal testing machine. The obtained data was statistically analyzed by using independent t test. **Results:** There was no statistically significant difference between fracture resistance values of FRC and PFS groups. 30% and 70% of the samples of PFS and FRC showed favourable fractures respectively. **Conclusion**: The fracture resistance of PFS was comparable to that of FRC post.

KEYWORDS

EverStick post
Spira-post
Fracture resistance
Mode of failure.

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1. Introduction

Endodontic treatment is mostly preferred on teeth significantly affected by caries and/or fracture. ETT are considered more brittle, when compared to their non-treated counterparts, due to moisture loss [1] and loss of collagen cross-linking in the dentin after endodontic treatment [2] and loss of structural integrity associated with the access preparation [3]. Successful treatment of such badly broken down teeth with pulpal disease depends not only on good endodontic therapy, but also on good post endodontic restoration. Therefore, there is a need to rehabilitate these teeth with techniques that will not compromise the integrity of remaining tooth structure with the use of post and core systems to retain full and final crown restorations [4].

Different types of posts have been evolved since past, which include custom made and pre-fabricated posts. Pre-fabricated posts may be either metal or non-metal posts. Conversely metal posts showed several shortcomings such as corrosion, inflammatory reaction, high incidence of catastrophic root fractures, discoloration.

Fibre-reinforced composite (FRC) posts were developed to overcome the disadvantages of metallic posts. The preference and popularity of FRC posts can be attributed to its elastic modulus which is similar to that of dentin so that the occlusal stresses are distributed evenly resulting in favourable root fractures that are easy to repair. They can be easily removed from the root canals in the cases of retreatment [5]. The other advantages are the adhesion and micromechanical bonding characteristics of these fiber posts to the resin luting agent, dentin, and composite core which gives life-like appearance.

Pre-fabricated glass fibre posts are available for many years but these posts have some disadvantages like require shaping of the canal walls to fit the dowels, leading to dentin loss which increases the incidence of root cracks and fractures, poor adaptability in oval, curved and flared canals [6].

The post and core system with poly fibre strands PFS called Spira-post (Zenith Dental, DMG America, USA) which naturally flexes to conform to the shape of the canal thereby it can be angulated to offer the benefits of a custom fit for different root canal configurations. Due to its unique design, Spira-post is able to adapt to the irregularities of the canal, so it minimizes the removal of tooth material. Spira-post has many more advantages such as being lesser technique-sensitive, highly esthetic, even distribution of stresses, easy removal during retreatment [7].

An elastic Fibre reinforced composite (FRC, everStick, GC, India) which is a soft, flexible and un-polymerized glass fibre post which can be individually adapted to the shape of the root canal whether it may be curved or oval as well as in widen canals. It can be angulated to certain degree, according to the altered existing occlusion to offer benefits of a custom fit for all root canal configurations. It has some added advantages: more tooth structure preservation, high flexural strength, elasticity very similar to the natural elasticity of dentine, even distribution of occlusal stress on the root structure thus reducing the risk of fracture [8]. The purpose of the present in vitro study was to evaluate and compare the fracture resistance between FRC and PFS post systems.

2. Materials and methods

Twenty single rooted maxillary central incisors were collected from the Department of Oral and Maxillofacial Surgery, and stored in 0.1% thymol solution.

2.1. Root canal treatment

Teeth were decoronated accordingly to maintain uniform tooth length of 16mm from root apex. After making standard access cavity preparations, root canals were instrumented up to ISO size 30 with 4% taper M two rotary files (VDW, Germany). At every instrument change, the root canals were irrigated with 3 ml of 3% Sodium hypochlorite (Prime Dental products, Mumbai, India) followed by 1 ml of 17% Ethylene diamine tetra acetic acid (RC help, Prime Dental PVT LTD, India) and final irrigation was done by 10 ml of 0.9% saline. The root canals were obturated with corresponding gutta percha (Dentsply, USA) up to 5mm of root length by sectional obturation technique using AH plus sealer. The specimens were randomly divided in to two groups with 10 specimens (n=10) in each group and then the root canals were cemented with fibre posts. The root canals cemented with Poly Fibre Strands (PFS) called Spira-post (Zenith Dental, DMG America, USA) and Fibre Reinforced Composite post (FRC, everStick, GC, India) were allocated to group I and II respectively.

2.2. Sample preparation for PFS

The post space was refined and enlarged upto gates Glidden (#4 Mani, Japan) according to manufacturer's instructions. The length of the remaining canal was measured using endodontic file and once the desired length was obtained, the Spirapost was measured and cut to the required length such that 4mm of the post was protruding out of the canal.

2.3. Sample preparation for FRC

The post space was refined and then everStick post foil bag was opened, and markings were made on the post according to the required length and the post was cut to a suitable length with sharp scissors. The length and suitability of the everStick post was checked by inserting it into the root canal till the post space and 4 mm of the post was protruding out of the canal. The fit of the post was finally checked and additional post material was shaped and attached tightly to the main post both coronally and inside the root canal by means of lateral condensation and the post was light cured before placing into the canal.

2.4. Cementation of post

The canal was rinsed to remove any debris and etched using 37%phosphoric acid and rinsed the canal with distilled water and dried using a paper point. The bonding agent was applied to the canal and the portion of the post being inserted into the canal. The canal space was filled with dual cure resin cement (Para core, Coltene, Mumbai, India) and post was inserted into the canal space using gentle pressure to allow any excess material to escape and the excess material was carefully removed and light cured for 40 seconds.

The core of dimensions 4x5 mm (length x width) was built using composite resin (Filtek, Z350 3M, ESPE, USA) according to manufacturer's instructions and final length of the prepared tooth was 6×5mm.

The samples were stored in saline for one week. All the samples were thermocycled for 500 cycles from 5 to 55 ^{0}c ±5 ^{0}c with a dwelling time of 30 seconds in each bath and a transfer time of five seconds.

2.5. Periodontal ligament simulation and fracture resistance test

To perform the compressive testing, each specimen was mounted in self cure acrylic block such that 1mm of root trunk is exposed and the socket was relined using poly vinyl siloxane impression material to simulate periodontal ligament. This specimen was placed into a fixation device (Jig) of universal testing machine (Instron 8801, USA) and a compressive load was applied at 45^{o} angulation on the palatal surface to the long axis of the tooth at a crosshead speed of 1mm/minute until failure occurred. The amount of the load required to cause failure was automatically recorded in MPa using the machine itself. The modes of fractures were also observed and were classified into supragingival and subgingival fractures. Supragingival fractures are considered favourable in which fracture line occurs 1mm above the acrylic resin. Subgingival fractures are considered unfavourable in which the fracture line occurs 1mm below the acrylic resin.

The data was collected and tabulated for statistical analysis. Statistical analysis of data was performed using the software statistical package for the social sciences (SPSS, version 20.0) and analyzed by independent t-test.

3. Results

Means and standard deviations were calculated for both the groups. The highest mean fracture resistance was demonstrated by the PFS (G-I) which showed mean fracture strength of 898.30±355.25MPa, followed by FRC (G-II) which showed mean fracture strength of 667.08±363.151MPa (Table1). The difference in the mean fracture resistance among the groups was found statistically insignificant (P=0.167). Maximum number of the samples (70%) in the FRC group (G-II) showed favourable type of fractures, where as in PFS group (G-I) 30%samples showed favourable fractures (Table2).

4. Discussion

The present in vitro study was attempted to evaluate and compare the fracture resistance and also the mode of failure of endodontically treated teeth restored with of two novel post and core systems; PFS post and FRC post.

Groups	Mean	SD*	P Value
PFS (G-I)	898.30	355.25	0.167**
FRC(G-II)	667.08	363.15	

Table 1. Comparison of fracture resistance. Where *Standard Deviation, **not statistically significant.

Groups	Favourable	Unfavourable
PFS (G-I)	3	7
FRC (G-II)	7	3

Table 2. Different modes of failures

In this study, the endodontically treated teeth with different fibre post systems exhibited superior fracture resistance. Among the post systems studied, endodontically treated teeth with PFS post showed highest mean fracture resistance (898.30±355.25 MPa). However, no statistical significant difference (P=0.167), was found between the groups.

The higher fracture resistance of PFS group was due to its innovative composite structure of surgical stainless steel wires twisted around natural colour poly fibre strands which can compress or expand according to the diameter of the canal which reinforces the remaining root structure which further improved the fracture resistance of the tooth[7] poly-fibre strands create a homogenous unit by integrating with resin cement and core material in the canal resulting in a mono-block type of restoration. This creates a strong structure that absorbs and distributes external forces, and minimizing the risk of failure. These strands does not hold memory, so there is no concern for undue stresses within the canal.

The presence of a high molecular weight polymethyl methacrylate chains in the FRC post act as stress-breaker. A-glycidyl methacrylate matrix, decrease stress concentration at the interface of fibre matrix during deflection, and absorption of emerging stresses through the matrix[9]. Also, during manufacturing of FRC posts, the rehabilitating effect of unidirectional impregnated fibres can be created. These impregnated fibres are soaked with resin matrix in a pre-stressed tension that released after curing causing fibres compression which can absorb the tensile stresses under Moreover, these fibres facilitate stress dissipation, supports the fillers of composite layers, and act as a crack stopper. The more increase of fibres in the matrix, the more increase of the post resistance to micro cracking. The bonding of FRC post with composite resin and also with the luting agent was improved by an interdiffusion bonding mechanism resulting in a 'Monobloc' type of restoration. This is attributed to the inherent character of the Interpenetrating polymer network (IPN) of the FRC post.

Comparing the modes of failure, more numbers of catastrophic/unfavourable failures were observed in group-I that is PFS group. Among the 10 samples in this group, 7 samples have reported subgingival fractures and the remaining 3 samples have reported supragingival fractures, which indicate 70% of the sample showed unfavourable fractures. Similarly, seven samples showed supragingival fractures and remaining three samples showed subgingival fractures among FRC post group. The results indicated that 70% fractures are favourable fractures.

The greater number of unfavourable fractures in Spira post group could be due to their structure of fibres and central metal core. The fibres which are too thin and flexible, couldn't withstand the forces for a longer time which resulted in uneven distribution and concentration of stresses along the metal core that have been transferred to the deeper and along the root structures resulting in catastrophic root fracture.

The greater number of favourable fractures in FRC post group was possibly due to similar elastic modulus of accepted range between dentin and everStick post resulted in equal dissipation of forces through overall length of the root without its fracture. Therefore, it can be attributed that FRC post act as stresses absorbers [11]. A layer of polymethylmethacrylate (PMMA) is present on the external surface of these posts. Adhesive resins which have solubility parameters close to that of PMMA can diffuse into the FRC post. Stick resin is one such adhesive resin that contains 2,2-Bis-[4-2-hydroxy-3-methacryloyloxy-propoxyphenyl-propane (bis-GMA), Tri-ethylene-glycol-dimethacrylate (TEGDMA), camphoroquinone and 2-dimethyl amino ethyl methacrylate. The bis-GMA and TEGDMA present in Stick resin have solubility parameters close to that of PMMA, thus enabling the penetration of the resin into the PMMA present on the outer surface of the FRC posts which becomes interlocked into the IPN polymer matrix after polymerization[12,13].

5. Conclusion

Within the limitations of the study, it can be concluded that fracture resistance of PFS post is comparable to that of FRC post. However, FRC group showed predominantly more number of favourable fractures.

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