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Research Article

Comparison of Fracture Resistance of Cast Metal Posts with Different Fibre Posts in Endodontically Treated Teeth- An *In Vitro* Study

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Received: September 08, 2023; **Published:** September 22, 2023

Abstract

Objectives: This study was undertaken to compare the fracture resistance of cast metal posts with different fibre posts in extracted teeth.

Method: Fifty intact maxillary, non carious extracted human single canaled central incisors were collected and stored in distilled water. Samples were divided into 5 groups(Group A (n = 10): Control group, Group B (n = 10): Cast metal post, Group C (n = 10): Prefabricated glass fibre post(Angelus Reforpost®) followed by composite core, Group D (n = 10): custom fibre post(Angelus INTERLIG®) followed by composite core and Group E (n = 10): custom fibre post(GC EverStick®) followed by composite core.)Ten teeth used as control which received only coronal preparation and remaining 40 teeth were sectioned transversally, close to the cemento-enamel junction, leaving a root length of 13 mm and were treated endodontically to receive posts and cores.

The samples were mounted in acrylic blocks and were tested for their fracture resistance with a compression testing machine.

Results: Highest mean fracture resistance was recorded in Group A, followed by Group E, then Group D and Group C. Group B recorded the lowest mean fracture resistance. The difference in mean fracture resistance was statistically significant among all the groups ($P < 0.05$).

Conclusion: Highest fracture resistance was recorded for Group A which was not treated endodontically and was our control group. The custom EverStick fibre post (Group E) showed the maximum fracture resistance among all other posts. The cast metal post showed the least fracture resistance among all the groups.

Keywords: *Fracture Resistance; Central Incisors; Posts*

Introduction

The restorations used for building up of endodontically treated teeth with much loss of hard tooth tissue is known as Post and Core restorations [1].

Such a restoration is needed when the dentin is insufficient to support the standard crown preparation [2].

The root canal operated teeth undergoes drying and dentin shows changes in collagen cross-linking, thus endodontically treated teeth are more prone to get fracture as they are brittle compared to non-endodontically treated teeth. Furthermore, any caries, trauma make such teeth more susceptible to fracture [1].

An ideal post and core should mimic the physical properties of natural dentin like modulus of elasticity, compressive strength and coefficient of thermal expansion. The post should be non-corrosive and should exhibit good bonding ability with dentin so that the entire family assembles to form an original tooth [1].

Post and core systems should be evaluated for their resistance to fracture as well as repairability to evaluate them for adequate clinical use [3].

Fiber post systems are biocompatible, exhibits good bonding to tooth structure, aesthetic and retrievable when the post and core fails [4].

Purton., *et al*. states that fiber post has increased transmission of light within the root and gingival apparatus, thus eliminating the darker hue caused by metal post systems [2].

Fiber posts are made of carbon, quartz or glass fibers, lying in a matrix of methacrylate or epoxy resin. A strong bond between these fibers and matrix enables load transfer and imparts good reinforcement properties in endodontically treated teeth [5].

Conditions with severely enlarged/elliptical root canals are encountered, prefabricated posts are not indicated rather customized posts are used that involve use of glass fibers to fabricated posts and resin composite to form the core. These custom post systems are directly luted with appropriate cement in root canal. These systems has added advantages of better geometric adaptation in canals, minimum tooth structure removal, more resiliency compared to prefabricated ones [6].

Among them, the E-glass fiber post (EverStick, Stick Tech Ltd) is one of the custom fiber posts used in this study that adapt to the bonded post spaces. It consists of E-glass fibers (52 - 56%) impregnated with a polymer-monomer gel consisting of Bis-GMA and PMMA [7].

This post is a resin impregnated flexible, unpolymerized glass fiber post.

Polymerizing this material produces elasticity similar to natural elasticity of dentine.

Another is the braided glass fibers impregnated with composite resin (INTERLIG; Angelus). Goldberg., *et al*. [7] introduced in the early 1990's this pre-impregnated FRC made of S-glass fibers and Bis- GMA resin matrix with impregnation of glass fibers.

It consists of glass fibers - 60 ± 5% impregnated with 40 ± 5% resin containing Bis-GMA, diurethane and barium glass [8].

It has been reported in other studies [7] that these posts create a monoblock effect and thus increases the flexural strength of complete tooth as a whole by working as a one unit post-core system. The unique properties of this glass post also make it possible to use this post in curved, oval and large root canals.

While using custom fiber posts excess shaping of root canals is not required to the same degree as with traditional posts. When the post is adapted to the morphology of root canal, its strength is maximized [7].

This study highlights the comparative evaluation of fracture resistance of cast metal posts, prefabricated glass fiber posts (Reforpost® Angelus) and custom made fiber posts (EverStick® GC) and (INTERLIG® Angelus) in endodontically treated teeth.

The null hypothesis tested was that fracture resistance and the failure pattern of these endodontically treated teeth were affected by the difference in structural composition (metal, FRC) of the posts.

Materials and Methodology

This study was done in Department of Conservative Dentistry and Endodontics, Daswani Dental College and Research Centre, Kota, Rajasthan, India.

Fifty-caries-free and restoration-free-human-maxillary central incisors with unhealthy periodontal conditions were extracted from the Department of Oral and Maxillofacial Surgery and Department of Orthodontics, Daswani Dental College and Research Centre, Kota, Rajasthan. The teeth were stored in distilled water immediately after extraction.

The extracted teeth were cleaned of soft tissue and debris surface. Debridement of all the teeth was done with hand scaling instruments and stored in saline at room temperature and the OSHA guidelines were followed for further management and storage of extracted teeth.

Inclusion criteria

- Fifty, non-carious freshly extracted maxillary central incisors were used.
- All the teeth were radiographed to exclude any teeth with more than one canal.
- Roots of similar form were selected.
- All these teeth were having a single canal and straight roots measuring approximately 16 mm.

Exclusion criteria

- Carious teeth
- Fractured teeth
- Teeth with open apex
- Previous restorations
- Previous endodontic treatment
- Pre-existing fracture or cracks.

Methodology

- Among the fifty non carious teeth selected; ten were the control group which did not undergo the endodontic procedure to receive the post. All these teeth had a single canal and straight roots measuring approximately 16 mm. The clinical crowns of forty teeth were sectioned transversally, close to the cement-enamel junction, leaving a root length of 13 mm. The remaining ten teeth stayed intact.
- The forty root canals were initially explored by introducing a #15 K file (Mani, Tochigi, Japan), and selected the specimens that had a working length of 12 mm. The preparation of the radicular canal was accomplished with Gates- Glidden drills (Mani, Japan) #1, #2. The biomechanical preparation (crown-down technique) of the root canal was carried out using the manual K files (Mani, Japan), and (up to) a number 55 master apical file was standardized for all specimens.
- During preparation, the canals were irrigated with 2 ml of 3% sodium hypochlorite (Nimai Dento, India), alternating with 17%

ethylene diamine tetraacetic acid (EDTA) (Prime Dental, India). Final irrigation was performed with 10 ml of distilled water, and the canals were dried with absorbent paper points (Mani, Tochigi, Japan). Root canals were obturated with master and accessory gutta-percha cones (Mani, Tochigi, Japan) and sealer AH plus (Dentsply, USA), using the lateral condensation technique.

- The excess of gutta-percha was removed by using heated condensers (GDC, United Kingdom). Vertical condensation was performed with the same instruments, and the pulpal chambers were sealed with provisional cement- Coltosol (Coltene/Whaledent, Switzerland).
- The roots were placed in cylindrical aluminium moulds and embedded in acrylic resin (Ashvin, India) to maintain 4 mm of root length. This root length was extended beyond the top of the acrylic resin. The ten teeth without endodontic treatment (whose crowns were not clinically removed) were embedded in the same way as the other specimens and constituted the control group.
- To fracture the teeth in compression testing machine, a customized jig (Table 1) was prepared to standardize the tooth position to be able to receive compressive loading at an adequate angle of 35° in relation to the long axis of the tooth applied on the cingulum of the palatal surface by the conical terminus of the jig.
- Grouping of the teeth specimens:
- Group A (n = 10): Control group
- Group B (n = 10): Cast metal post-1.1 mm
- Group C (n = 10): Prefabricated glass fibre post (Angelus Reforpost®)-1.1 mm
- Group D (n = 10): Custom fibre post (Angelus INTERLIG®)-2.0 mm
- Group E (n = 10): Custom fibre post (GC EverStick®)-1.2 mm.
- Custom cast posts: Though the traditional custom cast dowel core provides a better geometric adaptation to excessively flared or elliptical canals, and almost always requires minimum tooth structure removal. Custom cast post and cores adapt well to canals with extremely tapered canals or those with a noncircular cross section and/or irregular shape, and roots with minimal remaining coronal tooth structure and are still considered as the gold standard in anterior restorations.
- Prefabricated glass fibre posts: They have several advantages over metal posts- a one appointment technique, no laboratory fees, no corrosion, negligible root fracture, no designated orifice size, increased retention resulting from surface irregularities, conserved tooth structure, and no negative effect on aesthetics, Its optical properties make it an excellent aesthetic material and hence is compared in our study.
- Custom fibre posts (Group D and E): The reinforcing capacity of fibres depends on their adhesion properties, orientation of the fibers, and impregnation within the resin. Other desirable physical properties of the fibre are good flexural strength and no need for mechanical retention within the restoration and hence are compared in this study.
- Dowel spaces were prepared with peezo reamers starting with no. 1, 2 and 3 for all the forty teeth in group (B, C, D and E) except for the control group (A). The diameters used for different fibre posts in this study are different as, in group B (cast metal post) and C (prefabricated fibre post) the diameter is 1.1 mm, for Group D (Angelus INTERLIG), it is 2.0 mm, for Group E (EverStick post) it is 1.2 mm and the post space prepared for all the groups was same till peezo reamer #3.
- Since in our study we are comparing prefabricated posts with custom posts, diameter is of less concern because the filling of custom fibres in the canal to adapt the canal structure is entirely different placement technique compared to prefabricated posts.
- Following the post placement the core build up is done of a standard size. In this study, the post-supported cores were not restored with crowns so that the compressive load was directly applied to the inclined surfaces of the cores. In this manner, the probable altering of parameters, such as shape, material structure, length, and thickness, by crown restorations was avoided.

Core build up

- For composite core build up for groups C, D and E the length of the post coronal to the cement enamel junction was standardized to 6.0 mm using ruler and divider.
- (Coltene/Whaldent, USA) was used for core build up. Layers of composite resin (Coltene/Whaledent, USA) were applied successively around the dowel, and each layer (approximately 0.5 mm thick) was light-activated for 20 seconds to gain a composite core of height 6.0 mm. For cast metal group the core was fabricated along with dowel of 6.0 mm height and casted along with the dowel.

Fracturing the specimens

- The specimens were subjected to a compressive test in a compression testing machine (Instron, Instron Corp, Norwood, USA). A device (customized jig) (Table 1) was used to standardize the position of the specimens at the base of the apparatus. At this position, the load could be applied at an angle of 35 degrees in relation to the long axis of the roots. An increasing oblique compressive load was applied on the cingulum of the palatal surface (3.0 mm from the incisor region) by using a cylindrical-shaped device with a conical terminus (2.7 mm in diameter). A crosshead speed of one mm/min was applied until the root fractured.
- After fracture, all samples were assessed for failure mode by two independent and calibrated observers.
- 'Favourable fractures' were defined as repairable failures, including adhesive failures, above the level of CEJ. 'Unfavourable fractures' were defined as non-repairable fractures, including (vertical) root fractures, below the level of CEJ.
- The values (of the forces required for the roots to fracture) obtained in Newton (N) were submitted to preliminary-statistical tests to verify the normality of the distribution. Data analyses were performed using version 21.0 of the Statistical Package for Social Sciences (IBM Corporation, Armonk, New York, USA). One-way ANOVA parametric statistical test, Games-Howell post hoc test and chi-square test were used to analyse the data.

Comparison groups	Mean difference (N)	P value
Control and Cast metal post	738.10	P = 0.000 (<0.001), Sig. diff.
Control and Prefabricated glass fibre post	528.60	P = 0.000 (<0.001), Sig. diff.
Control and Interligcustom fibre post	325.30	P = 0.001 (<0.01), Sig. diff.
Control and EverStick custom fibre post	254.70	P = 0.007 (<0.01), Sig. diff.
Cast metal post and Prefabricated glass fibre post	-209.50	P = 0.000 (<0.001), Sig. diff.
Cast metal post and Interligcustom fibre post	-412.80	P = 0.000 (<0.001), Sig. diff.
Cast metal post and EverStick custom fiber post	-483.40	P = 0.000 (<0.001), Sig. diff.
Prefabricated glass fibre post and Interlig custom fibre post	-203.30	P = 0.000 (<0.001), Sig. diff.
Prefabricated glass fibre post and EverStick custom fibre post	-273.90	P = 0.000 (<0.001), Sig. diff.
Interlig custom fibre post and EverStick custom fibre post	-70.60	P = 0.000 (<0.001), Sig. diff.

Table 1: *Pairwise comparison of compressive strength (N) in different groups required for root fracture using Games-Howell post hoc test.*

Groups		Type of fracture		Total n (%)
		Favorable n (%)	Unfavorable n (%)	
Group A	Control	06 (60.00)	04 (40.00)	10 (100.00)
Group B	Cast metal post	00 (0.00)	10 (100.00)	10 (100.00)
Group C	Prefabricated glass fibre post	08 (80.00)	02 (20.00)	10 (100.00)
Group D	Interlig custom fibre post	07 (70.00)	03 (30.00)	10 (100.00)
Group E	EverStick custom fibre post	09 (90.00)	01 (10.00)	10 (100.00)
Yates' chi-square test		$\chi^2 = 16.354$, df = 4, P = 0.003 (<0.01), Sig. diff.		

Table 2: *Comparison of type of fracture between different groups.*

Preparation of specimens

Group A (Control group)

- The teeth of the control group (group A) were not submitted to endodontic treatment and did not have the crowns removed. This control group received coronary preparation with BR-45 round bur and SF-31 straight fissure diamond bur (Mani, Japan). The coronary preparation was standardized as 5 mm in height and 1 mm in width.

Group B (Cast metal post)

- In the cast metal post group, the dowels with core were prepared using direct technique with inlay wax and were invested in phosphate bonded investment material and were subjected to casting.
- Cast dowels were cemented with self-etch/self-adhesive-resin cement (Kerr (Maxcem Elite™), California, USA) The cement (Kerr (Maxcem Elite™)) was applied in accordance with the manufacturer's instructions. A lentulo-spiral instrument (Dentsply, USA) was used for the application of the cement inside the prepared canals. The premature polymerization of the resin cement (in the canal) was avoided by inserting the dowel immediately after the placement of the cement. Any excess cement was removed, and constant finger pressure was maintained for 60 seconds. A six minute waiting period allowed complete polymerization of the cement.

Group C (Prefabricated glass fibre post)

- The glass fibre dowels were cemented under the same protocol as was done for cast metal posts. Self-cure resin cement (Kerr (Maxcem Elite™)) was used for the cementation followed by composite core build up. the length of the post coronal to the cement enamel junction was standardized to 6.0 mm using ruler and divider; for composite core build up each post and coronal surface of teeth were acid etched (Unicorn Denmart (One Coat 7.0), India) for 30 seconds, rinsed with water, and dried with three-way syringe. Two coats of adhesive were applied, followed by 20 seconds of drying and light-activated with LED curing light (LY-B200 galaxy, India) for 30 seconds. Layers of composite resin (Coltene/Whaledent, USA) were applied successively around the dowel, and each layer (approximately 0.5 mm thick) was light-activated for 20 seconds to gain a composite core of height 6.0 mm.

Group D (Custom glass fibres post (Angelus INTERLIG®))

- The entire post was acid etched with 37% phosphoric acid (Unicorn Denmart, India) for 30 seconds and then washed dried with three way syringe. Bonding agent (One Coat SL, India) was applied with micro tip brush and cured for 40 seconds on each side.
- The composite (Coltene/Whaledent, USA) was adapted on to the post and just like during custom made post the entire unit was taken and inserted into the root canal. Then it was retrieved immediately and cured for 40 seconds all around. The post dimensions were adjusted by yellow ring finishing bur (Shofu, Japan).
- The canals were dried using paper points (PRIME Dental, India). Then the post was luted into the canal using self-cure resin cement (Kerr (Maxcem Elite™)).

Group E (Custom glass fibre post) (EverStick®)

- EverStick® post (GC, Japan, Sticktech Ltd. Turku, Finland) are available in three different sizes 0.9, 1.2 and 1.5 mm, for this study EverStick® post of size 1.2 mm was selected.
- First the depth of the prepared canal using an endodontic instrument or a periodontal probe was measured. The height of coronal structure required was also estimated.
- The coronal length was determined taking into account the final restoration. For this study the core size of 6.0 mm height is standardized. The post is pre-cut to a suitable length with normal sharp scissors.
- The length and suitability of the post was checked by inserting it into the root canal. If the post does not reach to the suitable length, the end of the post was tapered with a sharp scissors. The post is then fit into the root canal again. After shaping the post, it is light cured inside the canal for 20 seconds.
- In the upper portion of the canal, more than one post can be used to strengthen the post in areas of greater load. Any additional posts are shaped and bonded to the main post with a thin layer of enamel resin and light cured for 10 seconds inside the root canal.
- Then, the post is removed from the canal and light cured for 40 seconds, making sure that the post is cured on all sides. The post is then again fitted into the canal, ensuring that it reaches the appropriate depth.
- Then the post was coated thoroughly with resin cement to activate it. Prior to cementation, the resin surface is thinned, using a dry, oil free air, the post is then light cured for 10 seconds.
- The canal is then filled with the resin cement (Kerr (Maxcem Elite™)), California, USA) and post is inserted into the canal. After that cement is cured, the coronal part of the tooth is build up using composite resin (Coltene/Whaledent, USA) as for in other groups.

Statistical analysis

One-way ANOVA test was done to determine significant difference between the groups for fracture resistance, Games-Howell post hoc test was applied for pairwise comparison of groups. Shapiro-Wilk test showed that fracture resistance in different groups followed normal distribution but Levene test of homogeneity of variances showed that variances of groups were not equal hence One-way ANOVA with Welch correction was applied. Chi-Square test was done to show difference among different types of fracture.

Results

One-way ANOVA showed significant difference between the groups for fracture resistance (F = 519.763, P < 0.001).

1. Fracture resistance in group A (control) was significantly higher than any other group {group B (mean difference = 738.10 N, P < 0.001), group C (mean difference = 528.60 N, P < 0.001), group D (mean difference = 325.30 N, P < 0.01) and group E (mean difference = 254.70 N, P < 0.01)}.
2. Fracture resistance in group E (Everstick)was significantly higher than group B (mean difference = 483.40 N, P < 0.001), group C (mean difference = 273.90 N, P < 0.001), and group D (mean difference = 70.60 N, P < 0.001).
3. Fracture resistance in group D (Interlig) was significantly higher than group B (mean difference = 412.80, P < 0.001) and group C (mean difference = 203.30, P < 0.001).
4. Fracture resistance in group C (prefabricated post) was significantly higher than group B (mean difference = 209.50, P < 0.001).
5. Significantly highest fracture resistance was observed in group A (control) and lowest in group B.
6. In group A, 06 (60.00%) fractures were favorable and 04 (40.00%) were unfavorable. In group B all the fractures were unfavorable (n = 10, 100.00%). In group C, 08 (80.00%) fractures were favorable and 02 (20.00%) were unfavorable. In group D, 07 (70.00%) fractures were favorable and 03 (30.00%) were unfavorable. In group E, 09 (90.00%) fractures were favorable and 01 (10.00%) were unfavorable. Chi-square test showed Significant difference between the groups for the type of fracture (χ^2 = 16.354, df = 4, P < 0.01).

Discussion

On the basis of the statistical analysis of the data, the null hypothesis is accepted. There was a statistically significant difference between the post systems studied.

In this study, the post-supported cores were not restored with crowns so that the compressive load was directly applied to the inclined surfaces of the cores. In this manner, the probable altering of parameters, such as shape, material structure, length, and thickness, by crown restorations was avoided.

Dilmener., *et al*. in his study also considered that by eliminating such parameters, the structural integrity and fracture resistance of a post-and-core foundation could be tested more precisely [10,11].

The teeth in this study presented no remaining coronal dentin and no ferrule. This was done in order to create more challenging condition for the use of posts.

This was supported by other studies like conducted by Franco., *et al*. [12] who also did not leave any remaining coronal dentin and no ferrule.

It was stated that presence of at least 2.0 mm of remaining coronal dentin increases the resistance to fractures of teeth restored with prefabricated posts [12].

The anterior teeth has the occlusal forces of almost always below 200N. In the present study, the fracture load in all the groups were found to be superior to the ordinary chewing force and even greater than the minimum biting forces, therefore, it may be suggested that anterior teeth would resist normal occlusal forces [13,14].

In our study group A (control) showed the maximum fracture resistance, this can be explained with the fact that endodontically treated teeth show low fracture resistance because of the fact that these teeth are subject to coronal and radicular dentin loss due to carious destruction, root canal treatment, and/or extensive restorative procedures. There is evidence that these teeth also have reduced levels of proprioception which could impair normal protective reflexes ultimately leading to fracture [17].

In order to preserve the maximum dental structure, specifically such teeth were used which had been submitted to coronary preparation without endodontic treatment, as the control group. This was in support by other studies as conducted by Pasqualin., *et al*. [18].

Group A showed 60% favourability in fractures, this could be due to direction of propagation of fracture could be different for different teeth depending upon the enamel and dentin composition (mineral and organic content variation) for different teeth.

In group B (cast metal post) the mean load at which tooth fracture was recorded was lowest among all groups. One of the reasons for this could be since it is an inflexible material thus it could not bend and creates more stresses in the already compromised tooth structure resulting in early root fractures which are catastrophic in nature compared with other groups in our study [19].

The aesthetic property of these materials are limited since the grey coloured post is apparent and coupled with a high lip line, cast metal post-and-core foundations may result in aesthetic problems [20].

Other studies state that cast metal posts have a high modulus of elasticity compared to dentin which has the potential to transfer and concentrate the applied stresses to the surrounding compromised root structure [10].

The results obtained in our study were similar with that of study conducted by Ferrari., *et al*. which stated that unfavourable root fractures are the most common type of failure while using cast metal posts [21].

The cast metal post tested in the study by Perdigao., *et al*. transferred greater stresses to the root which could cause higher incidence of vertical root fractures which are unfavourable [22].

Mean fracture resistance recorded for group C was 563.30 ± 23.46N which was significantly higher than group B but low in respect to group D and group E.

The explanation for more fracture resistance for this group could be that the combination of prefabricated posts with composite core materials having a low elastic modulus (almost same to dentin) which evenly distributes stresses more equally to the surrounding tooth structure and preserves the surrounding dentin tissue from compressive loads.

The lower flexural modulus of fibre-reinforced posts (between 1 and 4 × 106 psi/(9-50 GPa2)) on the other hand, measures closer to that of dentin (≈ 2 × 106 psi/(14-18 GPa2)) and can decrease the incidence of root fracture. In the event of failure when restored with fibre reinforced posts, teeth are more likely to be restorable [1].

The average load of failure in this study was higher than the average load of failure found in other studies for prefabricated fibre posts [12].

Other studies state that forces in the tooth restored with a fibre post are apparently absorbed by the core and post and not transferred to the vulnerable root fracture. Another study found that a fibre post resulted in the lowest stress inside the root [22,24].

8 (80.00%) out of 10 teeth specimens in group C showed favourable fractures which failed because of cementation failure between the core and the remaining root dentin. This type of failure is considered reparable and has been reported in other studies.

This interfacial debonding between composite core and post may be due to the free space of the coronal root opening is filled only with weaker particulate composite resin cement.

Composite resin condensation around a post as in case of prefabricated glass fibre posts may cause probable voids or bubbles within the core or gaps at the post core interface resulting from a lack of condensation when placing the resin material around the posts may affect the integrity of the post-and-core foundation and consequently the compressive force resistance of the post-core foundation [10].

Previous studies are in agreement with the result obtained in our study which states that retrievable core fractures occurred in the groups restored with glass fibre posts [10,12,23].

It was noted that prefabricated fibre posts also have limitations in the properties such as poor anatomical fit to the canal, poor bonding to luting cement and in thin posts low fracture resistance, and therefore individually formed FRC posts have been compared in this study [25].

In one of the study prefabricated FRC posts have been criticized for their highly cross-linked polymer matrix, which is difficult to bond to resin luting cements and core material. This is due to the fact that the monomers of composite resin luting cements, which are used when bonding FRC posts, cannot dissolve, penetrate and swell the polymer matrix of the cross-linked character [22,25].

In an *in vitro* study, it was stated that FRC posts contain epoxy resins or methyl methacrylate, which seems to uptake water by diffusion and can cause some changes in post-core adhesion. Some studies reported that adhesion of these posts was improved after treatment with H_2O_2 and silane [26].

Due to all these drawbacks associated with prefabricated fibre posts, the evaluation of this group with custom fibre post (Group D and group E) was done and it was observed that custom fibre posts showed the maximum fracture resistance in our study.

Group D and group E showed the best results in comparison to other groups (Group B and group C), which can be attributed to the pre-impregnated fibres which aids in improved physical properties in terms of strength as well as aesthetics.

Baran., *et al*. stated in their review that the fatigue resistance of resin composite reinforced with glass fibres was increased because fibre reinforcements dissipates the stresses generated by the applied loads and they are able to arrest and/or deflect cracks.

Some studies have reached the same conclusion that FRC restorations can significantly increase fracture resistance through an increase in the flexural strength of the whole structure. The special orientation of the fibre network efficiently transfers stresses. It is practically supple and thus can be easily formed to the arbitrary configuration [7].

In our study the results obtained depict that group D has mean fracture resistance of 766.60 ± 29.81N which is higher than group C (563.30 ± 23.46N) but less as compared to group E (837.20 ± 20.94N).

Interlig-Angelus glass fibers are braided malleable glass fibers, preimpregnated with light-cured composite resin, easy handling, easy to cut (special scissors are not required) and adapt, packed in sachets to protect fibers from light and heat (3 Strips 85.0 * 2.0 * 0.2 mm) [27].

This FRC formulation based on "s" glass fibres with a heat polymerized BIS- GMA/PEGDMA matrix exhibited a flexural strength of 527 MPa [28].

In our study we found that Interlig could be built in increments and can be moulded and shaped until desired shape is achieved but the Everstick had to be built as one unit which was technique sensitive and difficult to handle.

Other studies also explained our results by stating that light polymerized formulation of these thermosetting FRC (Group D) which allowed for the creation of a segmentally built structure with each subsequent strip of FRC paced over the oxygen- inhibited layer of the previously polymerized FRC. In addition, particulate composite could be placed over and bonded directly to the oxygen inhibited layer on the surface of the completed and polymerized FRC structure which was not the case with thermoplastic Everstick glass fibre posts as they did not adequately bond to particulate composites and were difficult to handle [28].

In our study we evaluated that the results obtained in group E showed more fracture resistance compared to Group D where mean difference between the two was (- 70.60N, P,0.001).

One reason for this could be the ability of bonding resin to penetrate into the structure of IPN (interpenetrating polymer network) posts (Everstick) may give the opportunity to establish an adhesion between FRC post, luting cements and composite cores superior to that obtained with group D and could be the reason for its more fracture resistance than group D [29].

Also the improved adhesion of the resin cement by the inter-diffusion of monomers of the new resin into the polymer structure of the substrate or by free radical polymerization of the bonding resin to the unconverted double bonds of the remaining functional groups of the substrate. The likelihood of the later to occur is minor with conventional FRC root canal posts whose polymer matrix is typically based on epoxy. No chemical reaction of methacrylate based luting cements to the well-polymerized epoxy polymer occurs. On the contrary, there are difficulties in the adhesion of methacrylate based resin to the polymerized methacrylate composite substrates [7].

Thus, group D gives better bonding and creates a monobloc effect which resulted in higher fracture resistance compared to other groups.

Group D showed more favourable core fractures which could be explained on the basis that the fracture resistance depends on the close contact or the integrity between different materials which further depends on their surface texture and surface energy [10].

The coronal third of the post around which the core had to be adapted is filled with more interlig fibres giving more support to the composite core.

Freilich., *et al*. in his study coated the flexural strength of S glass fibres in the range of 453 to 936 MPa depending on the fibre volume fraction and L/D ratio and a particulate composite material tested with this demonstrated a flexural strength of 140 MPa.

In previous studies the fracture toughness of interlig fibres was 600.49 N which is in accordance with our study [28].

Fracture load in group E (837.20 ± 20.94N) was significantly higher than group B (mean difference = 483.40 N, P < 0.001), group C (mean difference = 273.90 N, P < 0.001), and group D (mean difference = 70.60 N, P < 0.001) but less than Group A.

According to Ng., *et al*. and Mezzomo., *et al*. teeth with less tissue damage have a greater resistance to fracture which was in support of our study as Group A showed highest fracture resistance (1091.90 ± 170.60N) [18].

However, the values fracture resistance of group E was nearest to group A with a mean difference of (254.70N, $P < 0.001$) which could explain the better characteristics of this custom FRC post and its close mimicking to the characteristics of a natural non endodontically treated teeth. It could be due to better adaptability to canal walls, better bonding and creation of a mono-block effect and that could withstand the fracture forces effectively.

Everstick is E-glass FRC polymerized by light and heat activation to a cylindrical form, presented the highest flexural strength values. This could be explained by the optimization of the polymer matrix and the fibre properties to function as a composite material. More precisely, the difference in the polymer matrix of Everstick compared to the matrices of other tested FRCs is based on the existence of PMMA (Polymethyl- methacrylate) chains in the cross linked polymer matrix. PMMA chains with a molecular weight of 220 kD plasticize the cross-linked bis-GMA based matrix of the EverStick FRC which structurally form semi-interpenetrating polymer networks (semi-IPN), and thus reduce stress formation in the fiber-matrix interface during deflection. This may be assumed to contribute to the higher strength of Everstick FRC material [30].

Well established dental polymers such as Poly (methyl-methacrylate) or PMMA and Bisphenol-A-glycidyl dimethacrylate or Bis-GMA exhibit an elastic modulus of 2 GPa and 9 GPa, respectively [7].

This may have influenced the situation where the stress by the polymerization contraction remained the slightly plasticised polymer matrix of the FRC post rather than caused high debonding stresses at the dentin-cement-post interfaces. It is also possible, that the lower polymerization rate of the semi-IPN resin systems allows the materials better to adapt to the root canal and post configuration. Once the resin system which forms semi-IPN polymer has been initiated, the reaction time to reach the final degree of monomer conversion is slightly longer than with cross-linking monomer system of Bis-GMA only [25].

According to a study conducted by Mannocci., *et al*. compared the penetration ability of bonding resins into fibre-reinforced composite posts and concluded that the bonding resins tested could effectively penetrate into the IPN structure of everstick FRC post whereas no penetration was observed in posts with cross linked polymer matrix of prefabricated FRC posts or with bis-GMA polymers [29].

The achievement of a good attachment between FRC post and composite materials used for luting of posts and for the crown build up of the core is of great importance in the restoration of endodontically treated teeth.

Further laboratory studies are needed to test this hypothesis. Prospective clinical studies are also needed to evaluate if the improved inter-diffusion of bonding resins into IPN polymer structure will result in clinical performances better than those obtained with the cross-linked glass FRC posts that are now extensively used in daily practice [29].

Narva., *et al*. in his study to investigate the fatigue resistance and stiffness of E-glass fibers used in Everstick post reinforced composite concluded a higher fracture resistance which is in agreement with our study [31,32].

The most efficient reinforcement can be obtained with continuous unidirectional fibres as observed in Everstick posts, which give anisotropic properties to the FRC. This means that optimal reinforcement can only be obtained when the direction of the stress is parallel to the direction of the fibres, meaning that the fibres are loaded in tension.

Bidirectional fibre as in Interlig (Angelus) weaves reinforce a material in two directions and give orthotropic properties to the FRC. Although the FRC is reinforced in different directions, the reinforcing efficiency is still dependent on the direction of the applied stress to the direction of the fibres. FRCs with short fibres in random directions exhibit isotropic properties, meaning that the fibre reinforcement is equal in all directions [7].

In group E, 09 (90.00%) fractures were favourable and 01 (10.00%) were unfavourable.

The mode of failure appeared as either an adhesive debonding between the FRC and the bonding composite or cohesive separation of the FRC near the bonded surface.

This separation was likely due to the swelling of the polycarbonate matrix by the PMMA monomer that was used to treat the internal aspect of the FRC before bonding [25,28].

An oblique loading at 30° was done in this study. Meira., *et al*. supports and explains in one of her studies the importance of oblique loading and an inverse relation of stresses with elastic modulus of posts. As in these cases the post tends to bend with a fulcrum located at the cervical region.

The lower the stiffness of the post, the more noticeable is the bending which leads to higher elongation of the post on the side where the load is applied [33].

These loads are below those expected during function when considering the masticatory forces reported by Niell., *et al* [34].

Conclusion

Highest fracture resistance was recorded for Group A which was not treated endodontically and was our control group. The custom EverStick fibre post (Group E) showed the maximum fracture resistance among all other posts. The cast metal post showed the least fracture resistance among all the groups.

Bibliography

1. Cheung W. "A review of the management of endodontically treated teeth". *Journal of the American Dental Association* 136 (2005): 611-619.
2. Purton DG., *et al*. "Effect of thermocycling on the retention of glass fiber root canal posts". *Quintessence International* 34 (2003): 366-369.
3. Fokkinga WA., *et al*. "A structured analysis of in vitro failure loads and failure modes of fiber, metal, and ceramic post-and-core systems". *The International Journal of Prosthodontics* 17.4 (2004): 476-482.
4. Newman MP., *et al*. "Fracture resistance of endodontically treated teeth restored with composite posts". *Journal of Prosthetic Dentistry* 89 (2003): 360-367.
5. Goracci C and Ferrari M. "Current perspectives on post systems: a literature review". *Australian Dental Journal* 56 (2011): 77-83.
6. Da Costa RG., *et al*. "Three-Year Follow Up of Customized Glass Fiber Esthetic Posts". *European Journal of Dentistry* 5.1 (2011): 107-112.
7. Keulemans F. "Exploring the limitations of fiber reinforced composite fixed dental prostheses: Fibres (un)limited". *Research Gate* (2016): 1-44.
8. Caixeta RV., *et al*. "Influence of glass fiber reinforcement on the flexural strength of different resin composites". *Applied Adhesion Science* 3 (2015): 24.
9. Chakmakchi M., *et al*. "In vitro comparative assessment of fracture resistance of roots restored with Everstick fiber reinforced composite post". *The Journal on Dispute Resolution* 2.1 (2015): 43-50.

10. Dilmener FT., *et al*. "Resistance of three new esthetic post-and-core systems to compressive loading". *Journal of Prosthetic Dentistry* 95 (2006): 130-136.
11. Peters MCRB., *et al*. "Stress analysis of a tooth restored with a post and core". *Journal of Dental Research* 62.6 (1983): 760-763.
12. Franco EB., *et al*. "Fracture resistance of endodontically treated teeth restored with glass fiber posts of different lengths". *Journal of Prosthetic Dentistry* 111 (2014): 30-34.
13. Salameh Z., *et al*. "The effect of different full coverage crown systems on fracture resistance and failure pattern of endodontically treated maxillary incisors restored with and without glass fiber posts". *Journal of Endodontics* 37.7 (2008): 842-846.
14. Pereira JR., *et al*. "The effect of post material on the characteristic strength of fatigued endodontically treated teeth". *Journal of Prosthetic Dentistry* (2014).
15. Assif D and Gorfil C. "Biochemical considerations in restoring endodontically treated teeth". *Journal of Prosthetic Dentistry* 71 (1994): 565-567.
16. Sorensen JA and Martinoff JM. "Intracoronal reinforcement and coronal coverage: A study of endodontically treated teeth". *The Journal of Prosthetic Dentistry* 51.6 (1984): 780-784.
17. Rezaei A., *et al*. "Comparison of stresses induced by fiber post, parapost and casting post in root canals by photoelasticity method". *Iranian Endodontic Journal* 5.1 (2010): 11-16.
18. Pasqualin FH., *et al*. "In vitro fracture resistance of glass fiber and cast metal posts with different designs". *The Revista Odonto Ciência* 27.1 (2012): 52-57.
19. Mishra L., *et al*. "Rehabilitation of fractured tooth by a custom made fibre reinforced composite post". *The International Journal of Odontostomatology* 6.3 (2012): 323-326.
20. Dilmener FT., *et al*. "Resistance of three new esthetic post-and-core systems to compressive loading". *Journal of Prosthetic Dentistry* 95 (2006): 130-136.
21. Ferrari M., *et al*. "Clinical evaluation of fiber-reinforced epoxy resin posts and castpost and cores". *Journal of the American Dental Association* 13 (2000): 15B-18B.
22. Perdigao J., *et al*. "The effect of dowel space on the bond strengths of fiber posts". *Journal of Prosthodontics* 16 (2007): 154-164.
23. Sahafi A and Peutzfeldt A. "Durability of the bond between resin composite cores and prefabricated posts". *Acta Odontologica Scandinavica* 67 (2009): 271-276.
24. Terry DA and Swift EJ. "Post-and-cores: Past to present". *International Dentistry SA* 12.2 (2006): 20-28.
25. Makarewicz D., *et al*. "Effect of cementation technique of indivisually formed fiber-reinforced composite post on bond strength and microleakage". *The Open Dentistry Journal* 7 (2013): 68-75.
26. Khamverdi Z., *et al*. "Effect of storage time on microtensile bond strength between quartz fiber post and composite core after different post surface treatments". *Journal of Conservative Dentistry* 14 (2011): 361-365.
27. Bechir ES. "Aspects in effectiveness of glass and polyethylene fibre reinforced composite resin in periodontal splinting". *Materiale Plastice* 53.1 (2016): 104-109.
28. Freeilich MA., *et al*. "Development and clinical applications of a light-polymerized fiber-reinforced composite". *The Journal of Prosthetic Dentistry* 80 (1998): 311-318.

29. Mannocci F., *et al*. "Penetration of bonding resins into fibre- reinforced composite posts: a confocal microscopic study". *International Endodontic Journal* 38 (2005): 46-51.

30. Lassila LVJ., *et al*. "Flexural properties of fiber reinforced root canal posts". *Dental Materials* 20 (2004): 29-36.

31. Narva KK., *et al*. "Fatigue resistance and stiffness of glass fiber- reinforced urethane dimethacrylate composite". *The Journal of Prosthetic Dentistry* 91 (2004): 158-163.

32. Bitter K., *et al*. "Effect of silanization on bond strengths of fiber posts to various resin cements". *Quintessence International* 38.2 (2007): 121-128.

33. Meira JBC., *et al*. "Elastic modulus of posts and the risk of root fracture". *Dental Traumatology* 25 (2009): 394-398.

34. Franco EB., *et al*. "Fracture resistance of endodontically treated teeth restored with glass fiber posts of different lengths". *The Journal of Prosthetic Dentistry* 111 (2014): 30-34.

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