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# Evaluation of different custom angulated elastic glass fibre post on fracture resistance of maxillary central incisor: an *in vitro* study

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**INFORMATION**

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**ABSTRACT**

**Background:** Restoring Endodontically treated teeth (ETT) can be challenging for most dentists, particularly when a significant tooth structure is lost. Depending on the coronal tooth structure remaining and the technique used (direct or indirect), endodontic anchorage can involve either a cast post and core or a prefabricated post.

**Aim:** This study aimed to investigate the effect of different custom angulated, i.e.,0°,5°,10°,15° elastic glass fibre post (Everstick post) on fracture resistance of maxillary central incisors.

**Materials and methods:** Forty A total of forty-eight single-rooted maxillary central incisors were selected. All the samples were decoronated 2mm above the Cemento-Enamel Junction and endodontically treated. Post-space preparation was done for all the samples using peesoreamers ranging in size from 1-3. The samples were then randomly divided into four groups (n=12) based on the different angulations, i.e., the angle between the core and the long axis of the root, with 0°, 5°, 10°, and 15° angulations, respectively. The fit of each post in the root canal was verified. Before cementation, the coronal part of each post was bent according to their respective groups. Dual-cure resin cement was used for luting the posts and cured subsequently. The fracture resistance of all the samples was evaluated using the universal testing machine after they were mounted in self-cure acrylic resin blocks. The data were analysed using One- way ANOVA and Tukey's post-hoc test.

**Results:** Group-I exhibited the highest mean fracture resistance compared to other groups. However, One-way ANOVA showed no significant differences ($p$=0.161) between the four groups.

**Conclusion:** Everstick fibre posts are a preferable alternative for maxillary central incisors with core angulations up to 15° between coronal and radicular segments as they provide better fracture resistance with a more favourable stress distribution.

## 1. Introduction

The anterior teeth are critical for the aesthetics, occlusal integrity, and phonetics of an individual [1]. A compromised smile can be evident due to missing, fractured, or discoloured anterior teeth, resulting in a loss of self-esteem [2,3]. The tooth fracture etiologies include protruded teeth, fall, contact game injuries, and road traffic accidents [4].

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Restoring Endodontically treated teeth (ETT) can involve either a cast post and core or a prefabricated post depending upon the remaining coronal tooth structure [5]. Prefabricated posts may be either metal or non-metal posts. Analysis of the available literature shows that the post's primary function is to anchor the core to the root, providing reinforcement to the root [5].

The angulation between the root and the crown, particularly of the single-rooted anterior teeth, is called the Collum angle or an angle formed by the intersection of the long axis of the crown and root using the lateral cephalogram is known as Collum angle [6]. Previous studies demonstrated that the Collum angle differs among groups with different types of malocclusions [7,8]. The orthodontists divided patients into four groups according to Angle's classification of malocclusion: class-I, class-II Division-I, class-II Division-II, and class-III malocclusions. The average value of the Collum angle for class-I malocclusion is 6.1±5.2, and for class-II division-I malocclusions is 5.3±4.2, and for class-II division-2 malocclusions is 10.6±4.4, and 5.6±5.1 for class-III malocclusions. Compared to groups with other malocclusion types, the Collum angle of natural teeth for patients with class-II division-2 malocclusions were the greatest [9].

In addition to the crown-root angle, the labial surface of the anterior teeth is comprised of two planes. The two-plane labial surface in the anterior teeth enhances the aesthetic proportion of the teeth by reducing the visible segment. During the restoration of the ETT with the post in the anterior teeth, dentists should take the crown- root angle and facial angle of the tooth into consideration. Since the fabrication of the endodontic post, following the long axis of the root will lead to proclined incisal edge position in the crown, incompatible contour, and loss of incisal guidance. Hence, it is imperative for the restorative dentist to fabricate the post with a similar crown-root angle of the adjacent teeth for optimum rehabilitation [10].

To overcome these difficulties, a novel glass fibre post, Everstick, was introduced. This post is a flexible, resin-impregnated uncured glass fibre with an Interpenetrating Polymer Network (IPN). Limited literature is available on different custom angulated elastic glass fibre posts on fracture resistance of maxillary central incisors. Hence, this in vitro study was designed to evaluate the effect of different custom-angulated elastic glass fibre posts on fracture resistance of maxillary central incisors.

## 2. Materials and methods

The sample size was estimated using G power software at a 95% confidence interval. The sample size obtained for this study was 12 specimens for four groups. So, a total of 48 teeth were included in the study [11].

### 2.1 Preparation and obturation of root canals

A total of 48 extracted human maxillary central incisors with single root and single canal were collected from the Department of Oral and Maxillofacial Surgery, Vishnu Dental College, Bhimavaram, Andhra Pradesh, India. The teeth with calcified canals, cracks or fractures, development defects, multiple canals, root caries, and endodontically treated teeth were excluded. In order to standardize the samples, the anatomic crowns with similar dimensions (i.e., a mesiodistal diameter of 7±1mm and a labiolingual diameter of 6±1mm) were selected. Teeth were stored in distilled water at room temperature to prevent dehydration until their use, and throughout the study.

All the specimens were decoronated transversally by preserving 2 mm of tooth structure above the cementoenamel junction (CEJ) with a double-faced diamond disc. In each tooth, access cavity preparation was made with Endo Access bur (Dentsply, USA), patency was established with 15K file (Mani, Japan). Working length was calculated by the visual method under 2.5X magnification using a Dental operating microscope by inserting a 15K file into the canal until it was first visible at the apical foramen and working length was established 1mm short of this length. Biomechanical preparation for all the samples was done in the crown down technique using ProTaper universal system (Dentsply Maillefer Switzerland). During canal instrumentation, intra-canal irrigation between each instrument was done with 2 ml of 3% sodium hypochlorite by using a syringe with 30-gauge side vented needle tips (Neoendo, India). All canals were finally rinsed with 1mL of 17% Ethylenediaminetetraacetic acid and followed by a final rinse with distilled water. All the canals were dried with paper points. The root canals of all the samples were obturated with corresponding Gutta-percha (Prime Dental, India) by sectional obturation technique with a minimum of 5mm of apical gutta-percha from root apex using AH Plus sealer.

Post-space preparation of 10mm in length was done with peesoreamers from sizes 1-3. Irrigation was done with 5ml of 17% EDTA for 15 sec followed by 5ml of distilled water and dried with the paper points. All the teeth were randomly allocated into the following four groups (12 per group). All teeth were to be restored with a 1.5mm diameter Everstick post.

Group-I (n=12): The angulation of 0° core to the long axis of the root.
Group-II (n=12): The angulation of 5° core to the long axis of the root.
Group-III (n=12): The angulation of 10° core to the long axis of the root.
Group-IV (n=12): The angulation of 15 °core to the long axis of the root.

### 2.2 Placement Procedure of EverStick-Post

Posts were cut together with the silicone strap to the length of 14mm using sharp scissors. After cutting the posts to the required length, the posts were removed from silicon strips using tweezers, and the length was checked by inserting the post into the root canal space so that each post protrudes 4mm from the sectioned tooth surface. For appropriate fitting of the post into the prepared post space, additional Everstick fibres were added to the post space.

### 2.3 Fabrication and angulation of posts in each group

2.3.1 Group-I
The fit of each post in the root canal was verified; if the post does not reach the necessary depth, the apical end of the post was tapered with sharp scissors to fit in to post space. Before cementation, the coronal part of each post was placed at an angle of 0°. The angle between the long axis of the radicular part of the post segment and the coronal part of the post segment was kept at 0° by placing the teeth along with the post on a reference paper on which the angulations were drawn with the help of a protractor. After drawing the reference angulations on a paper, a glass slab is placed in 0° angulation, and the coronal part of the post segment is adjusted accurately to the required angulation by adapting to the glass slab.

2.3.2 Group-II
After drawing the reference angulations on paper, a glass slab is placed in 5° angulation, and the coronal part of the post segment is adjusted accurately to the required angulation by adapting to the glass slab.

2.3.3 Groups-III and -IV
After post space preparation, the post was placed as described in Group - I and Group - II with 10° and 15° angulations, respectively.

### 2.4 Post and Core fabrication

Fibre posts were pre-cured for 20 seconds within the canal to stabilise the angulation of the post's coronal portion, then removed and cured for 40 seconds. Then canal spaces of all the specimens were etched with 37% phosphoric acid (N etch gel, Ivoclar Vivadent, USA) for 15 seconds and then rinsed with distilled water and dried using a paper point. The fibre post was activated by applying an enamel bonding agent (StickRESIN GC, Germany), and the post was placed under a light shield for 3-5 minutes to prevent premature curing. Then the post was light-cured for 10 sec. Dual Cure Resin Modified GIC cement (Relyx luting 2, 3M ESPE, USA) was mixed for 20 seconds and applied to the canal walls. A thin layer of cement was placed on the post surface, and the post was inserted into the canal. Excess cement was removed, and the remaining cement was light-cured for 40 seconds using a LED curing light (Woodpecker, China) at an intensity of 800 $mW/cm^2$.

After cementation of posts, all the samples were etched with 37%phosphoric acid (N etch gel, Ivoclar Vivadent, USA) for 15seconds and then rinsed with distilled water and dried. A bonding agent (Tetric N Bond, Ivoclar Vivadent, USA) was applied with a micro brush, and excess was removed with gentle air blow and then light-cured for 20 seconds using a LED curing light at an intensity of 800 mW/cm2 according to the manufacturer instructions. Then standardized cores were restored using a resin core build-up material (Filtek Z350 nanohybrid composite (3M, ESPE, USA) with a height of 8mm measured from labial CEJ. The total core height comprised of 6mm of the core material and a prepared dentine ferrule that measured 2mm labially and 1mm proximally.

For all the samples to simulate the periodontal ligament, the roots were wrapped with adhesive tape to a depth of 2 mm below the CEJ and were mounted in self-cure acrylic resin blocks to a level 1mm apical to CEJ such a way that the coronal part of the post is parallel to the long axis of the mold to make the root tilts correspondingly.

**Table 1. Mean fracture resistance (in N) and standard deviations of all 4 groups (One-way ANOVA)**

| Groups | N | Mean ± SD* | F - Value | Significance (*p*-value) |
|---|---|---|---|---|
| Group-I | 12 | 351.78 ± 115.75 | 1.799 | 0.161 |
| Group-II | 12 | 349.64 ± 105.44 | | |
| Group-III | 12 | 336.93 ± 78.31 | | |
| Group-IV | 12 | 273.55 ± 74.97 | | |

*Standard Deviation

**2.5 Testing of samples for fracture resistance**

All the specimens were subjected to a fracture resistance test using a Universal testing machine (Instron 8801, United Kingdom) at a crosshead speed of 0.5mm per minute. The acrylic blocks were secured in a prefabricated jig, which allows the plunger to apply the load on the palatal surface 3mm below to the incisal edge at an angulation of 130° to the long axis of the tooth. The load was applied until the specimen was fractured. The obtained data were subjected to statistical analysis using Statistical Package for Social Sciences, Version 22.0, USA.

## 3. Results

The mean fracture resistance (N) and standard deviations (SD) of all four groups are given in table 1. The Group–I (0°angulation) demonstrated the highest mean fracture resistance followed by groups-II, III and IV, respectively (Table 1). One-way ANOVA exhibited no statistically significant differences ($p$=0.161) among the groups (Table 1). Posthoc analysis also showed no statistically significant differences between the groups.

## 4. Discussion

The reconstruction of endodontically treated teeth is a great challenge in restorative dentistry since the tooth structure is totally or partially lost by caries, erosion, abrasion, previous restorations, trauma, or endodontic access [12]. The restorations of endodontically treated teeth are designed to protect the remaining tooth from fracture, prevent reinfection into the canal system and replace the missing tooth structure [13]. We often come across patients with fractured proclined anterior teeth seeking aesthetic corrections to improve their smiles. Several studies have reported the predominant prevalence of traumatic dental injuries in patients having such proclined teeth. Children and adolescents presenting inadequate lip closure or an increased overjet greater than 5mm is more likely to suffer from such dental traumatic injuries [13].

The utilization of post as a post endodontic restorative technique is usually recommended for mutilated endodontically treated teeth. If tooth structure loss is more than 50%, it would determine the use of posts to retain the core and distribute stresses [14]. The primary function of a post is to retain the core that replaces the missing coronal structure without compromising the apical seal of the root canal filling. Ideal post-core systems are expected to evenly distribute the functional force along the root surface. For better force distribution, the post should be as long as possible without endangering the apical seal [15].

For long-term success, there is a need to conserve the remaining healthy root structure. The reason for this change of paradigm is to achieve a more conservative approach with minimally invasive preparation and maximum tissue conservation, which is considered the gold standard for ETT. It is essential to select a post system that provides maximum retention to the core and requires removing the minimal amount of tooth structure. The recently introduced Everstick post system is a unique post made of impregnated fibres that can adapt to the shape of any root canal and avoid extensive preparations.

The maxillary anterior teeth with two plane labial surface and variation in coronal-root curvature necessitate the fabrication of post with different angulation between coronal and radicular segments [10]. Earlier research reports indicate the significant differences in the crown-root angles of maxillary central incisors among various malocclusions. The collum angle is described to range from 5°-15° between different malocclusion groups [7,8]. Hence the custom post with the crown-root angle of 0°, 5°, 10°, and 15° were selected for evaluation in the study.

The present in-vitro study was done to evaluate the effect of different custom angulations, i.e., 0°, 5°, 10°, 15° of elastic glass fibre post (Everstick post) on fracture resistance of maxillary central incisors. Statistically, no significant difference was observed between the groups in the mean fracture resistance. This may be due to the close elastic modulus of the Everstick post to dentin that flexes together under loading force. Also, the dentin-like behaviour of the post facilitates better stress distribution and yields high fracture strength values. In addition, several factors might influence the mechanical properties of FRC posts as the type of polymer matrix and length, diameter, number, and fibre-orientation of embedded fibres.

The presence of high molecular weight polymethyl methacrylate (PMMA) chains in the Everstick post act as a stress-breaker via plasticize the stiffness of highly cross-linked bisphenol A-glycidyl methacrylate matrix (Bis GMA), decrease stress concentration at the interface of fibre-matrix during deflection, and absorption of emerging stresses through the matrix. The silanized fibre of Everstick is another essential method for improving the fiber/matrix interface strength [16].

The multiphase polymer matrix of these Everstick posts consists of both linear and cross-linked polymer phases (semi-interpenetration polymer network, semi-IPN). The monomers of the adhesive resins and cement can diffuse into the linear polymer phase, swell it, and polymerize, form interdiffusion bonding and a so-called secondary semi-IPN structure; this will be reduced stress formation at post/dentin and post/cement interfaces [13].

The interpenetrating network of Everstick post is designed to improve the bond between the post and the resin and to prevent adhesive failures and microleakage. The bonding of the fiber-reinforced post (FRC) with the Interpenetrating network resin matrix to the composite resin and adhesive cement was improved by an interdiffusion bonding mechanism resulting in a "Monobloc" type of restoration [17]. Everstick posts can be adapted easily to the shape of the root canals, thereby possibly reducing the number of voids and then the canal completely filled with post; for this reason, the adhesive surface, and the strength in the most critical part of the tooth are maximized [11].

The Everstick post system allows the additional number of unpolymerized posts to be added according to the canal morphology, which leads to better adaptation and better stress distribution. The root canal, which is completely filled with fibers is considered as a more effective reinforcement than one post only when compared under the same polymerization procedure [18].

According to the results from the study, the mean fracture resistance had a positive linear correlation with the decreased angle between the core to the long axis of the root. This could be due to the increased angulations; the off-axial forces seem to outweigh the axial forces, resulting in excessive tensile stress concentration resulting in decreased fracture resistance as obtained in this study [13].

The results obtained in this study were not in accordance with a previous study done to evaluate the fracture resistance of proclined endodontically treated teeth with cast metal post and Everstick post. The results of this study showed that 10°core to the long axis of the root group showed a mean fracture value higher than the 0° group. However, there was no statically significant difference between the two groups. In this study, porcelain fused metal crowns were fabricated for all the specimens. The crowns may act as a greater equalizer of forces because it tends to change the distribution of forces to the root, post, and core complex, with the post characteristics become insignificant [19].

According to Ferrario *et al.* (2004) [20], the normal biting force exhibited by the maxillary central incisors is in the range of 93 – 146 N. However, the mean fracture strength values obtained in this study were much higher than the anterior bite force encountered under normal clinical loading conditions. So, changing the core angulation up to 15° can be carried out safely using Everstick post systems as tested in the study.

However, further *in vitro* and *in vivo* studies with larger samples and teeth with more complex anatomies are needed to corroborate the results of the present study and to evaluate its clinical efficacy and applications.

## 5. Conclusion

Restoration of endodontically treated maxillary central incisors with Everstick post, there was a decrease in the mean fracture resistance with an increase in core angulation. However, there was no statistically significant difference in the mean fracture resistance among the four experimental groups, i.e., 0°,5°,10°, 15°

core angulations. It can be concluded that Everstick fibre posts could be an alternative for restoring endodontically treated maxillary central incisors with core angulations up to 15°.

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