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RESEARCH ARTICLE

A Comparative Evaluation of Fracture Resistance in Endodontically Treated Teeth Reinforced by Novel Hybrid Post and with Various Pre-Fabricated Post Techniques: An *In-Vitro* Study

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ABSTRACT:
Introduction: Teeth with a final post-endodontic restoration cannot support significant structural loss brought on by fracture, caries, big pre-existing restorations, or aggressive cavity preparation. Post and core restoration allows for the restoration of such teeth. Reduced dentine size, moisture, and compromise on supporting structures such the oblique bridge, marginal ridges, and pulp chamber roof result in a reduction in their resistance because of structural loss. Under such circumstances, choosing a good post-endodontic restorative material can be difficult.
Materials and Methods: In terms of post-treatment procedures, 40 single-rooted decoronated mandibular premolar teeth were endodontically treated and randomly divided into four groups. As a control, the first group had a composite core but no post; groups two and three had prefabricated metal threaded posts; group four had prefabricated hybrid posts. The posts were affixed using dual-cure resin cement, and the core build-up material was nano composite. Each group's core structure was standardised, and metal crowns of the same size were used to reinforce it. A universal testing machine was used to test every specimen, and the fracture load was tabulated.
Statistical analysis used: one way ANOVA analysis
Results: The highest failure load was found with prefabricated hybrid post. This group had significantly higher load compared to other post groups. Followed by prefabricated fibre post and prefabricated metal threaded post.
Conclusions: Fracture resistance of endodontically treated teeth reinforced with hybrid post showed significant values when compared to that of prefabricated glass fiber posts, prefabricated threaded post and control teeth.

Key-words: Endodontically treated teeth, fibre post, fracture resistance, hybrid post, metal threaded post

Introduction:

The main etiological factors that cause coronal tooth structural loss are caries and trauma. If there is significant tooth loss, a permanent restoration cannot be supported. Tooth structure loss may also interfere with masticatory function and cause discomfort for the patient[1]. This will demand endodontic operations on the teeth. Endodontically treated teeth with insufficient residual coronal tooth structure require extra strengthening to improve retention and resistance to definitive restoration. Teeth with a final post-endodontic restoration cannot support significant structural loss brought on by fracture, caries, big pre-existing restorations, or aggressive cavity preparation. Reduced dentine size, moisture, and compromise on supporting structures such the oblique bridge, marginal ridges, and pulp chamber roof result in a reduction in their resistance because of structural loss[3]. Under such circumstances, choosing a good post-endodontic restorative material can be difficult[4]. Post and core restoration allows for the restoration of such teeth. A post is typically used to improve core retention, which in turn improves crown retention[2].

The success of the endodontically treated teeth depends mainly on the post endodontic restoration than the endodontic treatment quality as suggested by Trope and Ray [5].

Most endodontically treated teeth, according to Turner CH et al, need intra-radicular devices to recover their original function[6]. The use of prefabricated post systems allows for a wide range of post systems, from the traditional custom cast post and core to one-visit approaches[7,8]. Pre-fabricated posts and cast custom posts are the most often used post and core designs. Prefabricated posts appear to be most beneficial in teeth with a significant amount of coronal dentin retained; in these cases, the core can be composed of materials that retain to dental tissues. Cast post and cores are frequently recommended for teeth with limited surviving coronal structure or for uniradicular teeth with less coronal height. Several prefabricated post systems have been developed during the past few decades. But, this article introduces a brand-new, cutting-edge post that is prefabricated with customised fit and is known as HYBRID POST (Fig. 1). The manufacturing of a hybrid post is designed by scanning a piece of gutta percha with the necessary master apical size, such as protaper gutta percha of F2 or F3, to create an STL (Standard Tessellation Language) digital file which was then programmed to CAD (computer aided designing) to make a model of post by MLS (metal laser sintering) (Fig. 2).

The selection of material and design is important, because it may influence on the long life of the tooth[9]. Hence, the aim of this laboratory study was to compare the fracture resistance of endodontically treated teeth restored with various prefabricated post and novel hybrid post system with different amounts of dentine removal.

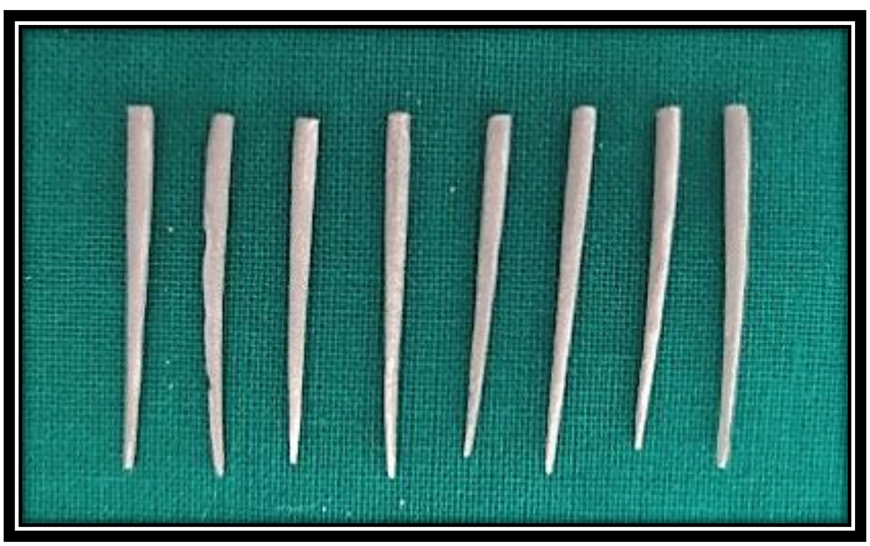


Figure 1: Hybrid post

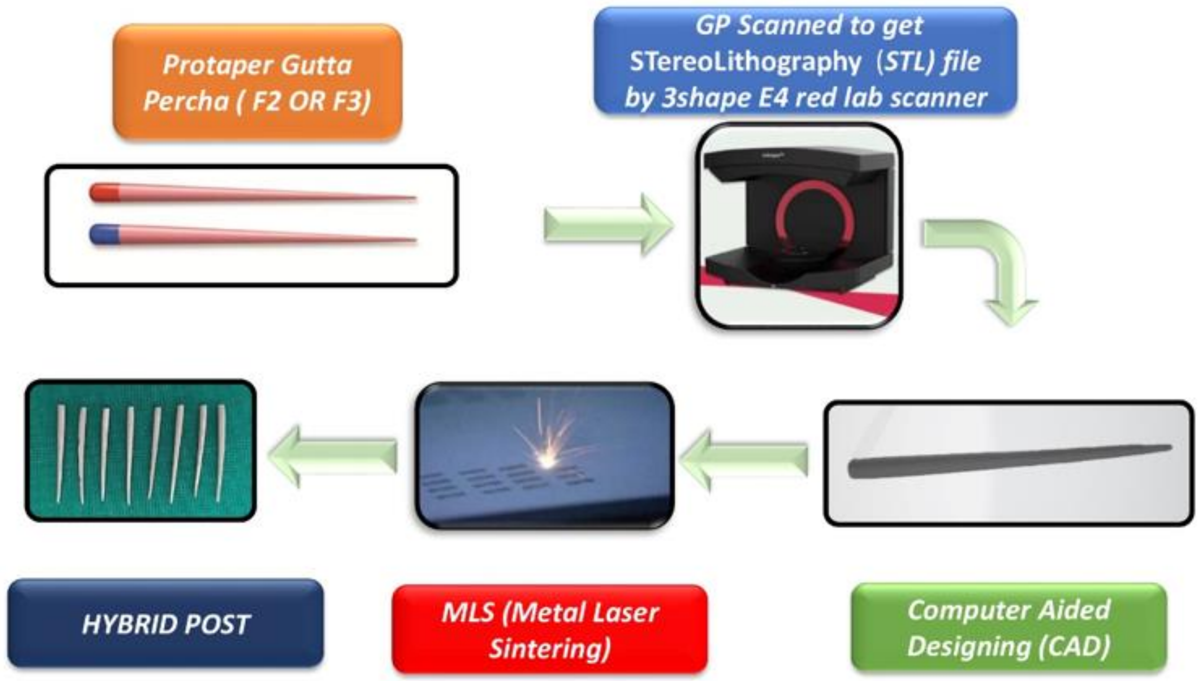


Figure 2: Hybrid post manufacturing from scanning gutta percha to cad milling process

Materials and Methods:

For storage in 0.9% saline solution, 40 extracted permanent human mandibular first premolars with a single root were chosen. The study did not include the teeth that had evident cracks, caries, or developmental abnormalities. To standardise the size and thickness of the roots, measurements of the facial-lingual and mesio-distal dimensions of the root section were taken. Teeth that deviated by more than 10% from the root criterion (4.5 mm for mesio-distal and 6 mm for facial-lingual) dimensions were disqualified. To standardise the length at 15 ± 1 mm, teeth were decoronated horizontally at the cementoenamel junction (CEJ) using a diamond disc and a slow-speed handpiece with water cooling. Teeth are randomly divided into four study groups with 10 samples in each group. Group-1 no post, Group-2 prefabricated fibre post (angelus USA), Group-3 pre-fabricated metal threaded post (Nordin swiss), Group-4 Hybrid metal post (Fig. 1,2).

Cleaning and shaping

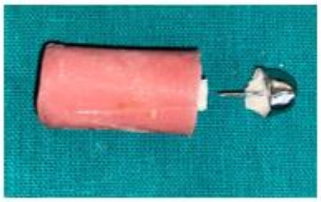
Using a rotary file system, cleaning and shaping were carried out (Protaper universal, dentsply). 0.9% Normal Saline W/V was utilised for irrigation during canal enlargement up until the F2 position, and 17% EDTA (Prime Dental, RC Help) was used as a chelating agent during biomechanical preparation. Intermittent irrigation with 3% sodium hypochlorite was done, with a final rinse using 5 mL of sterile water. In groups 1, 2, and 3, the canal was obturated with lateral condensed gutta-percha (Denstsply), while group 4 underwent sectional obturation using a resin sealer (AH26, Dentsply Maillefer, Ballaigues). Canal orifices were closed with cavit (3M ESPE) and kept in normal saline for 48 hours. By using a No. #4 peeso reamer(Manni Tochigi-Ken/JAPAN) to flare the post-space to a standard size, the preparation was completed for group 2 and group 3. And no post space preparation in group 1 and group 4.

Post cementation

Before cementing, the canals were cleaned with water for 30 seconds and then dried with paper points. At least 20 seconds of 37% phosphoric acid etching were performed, followed by 15 seconds of water rinse. To completely cover all the inside surfaces of the prepared canal, a single component total-etch (SDI, Australia) was used. After that, it was gently blow-dried for 10 seconds to maintain the surface moist and light-cured. In groups 2, 3, and 4, posts were cemented using dual-cure resin cement in accordance with the manufacturer's instructions. As posts are not used, the control group's root canals were not prepped for post space, 2 mm of gutta-percha was not removed from the root canal space, and core build-up was not done.

Fractured tooth specimen in control group

Fractured tooth specimen reinforced with threaded post



Fractured tooth specimen reinforced with hybrid post

Fractured tooth specimen reinforced with fiber post

Figure 3: Fracture of samples using a universal testing machine

Core buildup
Each group's coronal section was uniformly constructed using prefabricated core formers that were shaped to resemble lower first premolars. Here, prefabricated core formers and dual-cure composite cement were used on purpose to build up the core since they duplicate the same size and allow for standardisation. Moreover, the direct metal laser sintering technology is used to create metal crowns of comparable dimensions.

Fracture resistance
To replicate a periodontal ligament with a thickness of 0.2 millimetres, the specimen's root section was twice wrapped in aluminium wrap. At 2 mm from the buccal CEJ, each specimen was embedded in a dental self-curing acrylic block of 2 cm by 5 cm. The specimens were put through testing for fracture resistance. With a universal testing machine, the compressive load was delivered to the premolars' occlusal surfaces at a 90° angle and a crosshead speed of 1 mm/min to the long axis. Each sample examined had its fracture strength measured in Newton's (N). Failure threshold was described as the moment at which the loading force reached its maximum level, which could result in the root breaking, the post bending, or the cement breaking loose (Fig. 3).

Statistical analysis
Statistical analysis was performed using SPSS version 20 software (IBM SPSS, IBM, Armonk, NY, USA). Descriptive statistics, one-way anova tests were done to analyze the study data as mentioned in Table 1: Compressive strength of each group subjected to universal testing machine and Table 2: Bar chart showing the fracture resistance comparison of each group

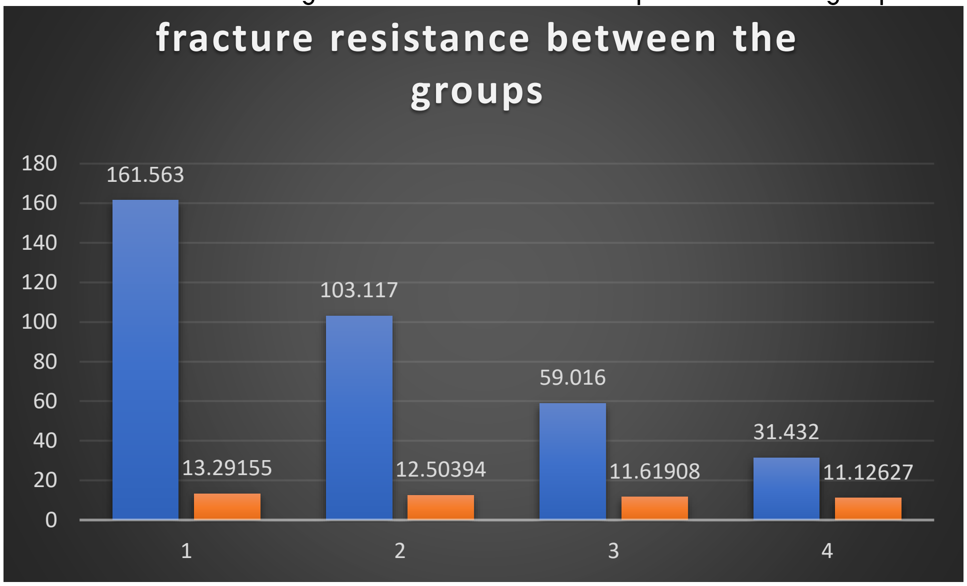
Table 1: Compressive strength of each group subjected to universal testing machine

DESCRIPTIVE

COMPRESSIVE STRENGTH

	Number of samples	**Mean**	**Standard Deviation**	**Standard Error**	**Values**	
					F value	significance
Hybrid post	10	161.5630	13.29155	4.20316	218.034	.000
Fibre post	10	103.1170	12.50394	3.95409		
Threaded post	10	59.0160	11.61908	3.67428		
Control group	10	31.4320	11.12627	3.51843		
Total	40	88.7820	51.16648	8.09013		

Table 2: Bar chart showing the fracture resistance comparison of each group



Group1 -Hybrid post
Group2-Fibre post
Group3-Threaded post
Group4-control group

Results:

The highest failure load was found with prefabricated hybrid post (161.56 ± 15.40 N). This group had significantly higher load compared to other post groups. Followed by prefabricated fibre post (103±14.20 N) and prefabricated metal threaded post (159.05±15.20). The composite core control group with no post had the lowest fracture load compared to all other groups (31.43 ± 14.03 N) and was statistically different from other groups (Group II, III and IV). The mean and standard deviation of load failure in different groups are listed in Table 1 and bar chart listed in table 2.

Discussion:

Franklin Weine claimed that the majority of endodontically treated teeth frequently failed following root canal therapy in arrears to post endodontic restoration[10] rather than the basic endodontic cause. This study assessed the fracture resistance of teeth that had undergone post-endodontic restoration using a variety of posts and a unique hybrid post system with minimal dentine wall preparation. The fracture resistance of this in vitro inquiry has been planned in accordance with the advice of Anusavice et al. while maintaining structural representative specimens that are as close to clinical reality as possible [11].

Post endodontic restorations might fail for a variety of reasons. The use of large-diameter posts increases the risk of apical or lateral perforation and is the primary cause of complications[12]. One of the most important preparation elements and one of the most frequently overlooked—is post width. The reasons for choosing the post width are to preserve dental structure, lower the risk of perforation, and enable the restored tooth to withstand fractures[13]. Many researchers have suggested various methods for choosing the post diameter[14,15]. These methods were categorised by Lloyd and Palik[17] into three groups: proportionist, preservationist, and conservationist methods. According to Stern and Hirshfeld[18], the post width shouldn't be more than one-third the root's width at its narrowest point. It was advised to use this proportionist technique to keep enough tooth structure. Other researchers have suggested the preservationist approach, according to which the post must be encircled with sound dentin that is at least one-millimetre thick[19]. Pilo and Tamse recommended restricting the post diameter to preserve the remaining tooth structure as part of a conservationist strategy since they encouraged limited canal preparation and keeping as much residual dentin as feasible[16]. Using a conservative strategy that was backed by numerous research led to the best results in terms of fracture resistance. The tooth restored with large diameter posts is reported to provide the least resistance to fracture with a decrease in the width of the remaining dentin[13].

A new, revolutionary post has been created with no preparation in mind, allowing it to perfectly adapt to the biomechanical preparation of a tooth that has undergone endodontic treatment thanks to technological breakthroughs. Unlike other prefabricated posts, these hybrid posts can be machined to the master apical gutta percha size to match the final canal preparation. The adoption of a hybrid post can eliminate the need for excessive dentine removal for passive posts and craze lines in active posts after installation[20].

The roots of the maxillary centrals and laterals as well as the mandibular premolars have considerable bulk, according to Gutmann, who studied the anatomic concerns in some depth[21]. The preparation of the post space in posterior teeth is more difficult due to the narrower canal structure. Because less dentin is removed and the tooth's ability to withstand fracture is increased, the choice of post may be more conservative if it closely matches the architecture and shape of the canal[22].Hence, since hybrid posts do not need post space preparation and may be used in narrow canals with a conservative approach, they have better anatomical adaptability for the success of post core restoration.

It has also been thought about how post width affects retention and fracture resistance. It has been demonstrated that a wider post has no appreciable impact on retention[23]. With a reduction in the width of the remaining dentin, it is claimed that the tooth restored with larger diameter posts offers the least resistance to fracture[18]. Holmes et al.[24] have shown that the variation in post dimension greatly influences shear stresses, which results in a reduced width of hybrid post space as no post space preparation apart the biomechanical preparation helps in custom fit and because its prefabricated custom fit it require less chair side time. Reduced shear loads and the preservation of tooth structure can be achieved by lengthening the post while maintaining a small diameter. This reduces the endodontically treated tooth's susceptibility to fracture, allowing for the placement of hybrid posts with a minimum post width and maximum post length for restoration purposes. Enhancing retention, distributing stress, and sealing imperfections between the tooth and the post are all significantly improved by cementation[25]. The rise of hydrostatic pressure during cementation has been found to produce an increase in stress within the root canal[26]. Yet, these tapered hybrid posts are self-ventilating and will allow the cement to spread evenly throughout the entire surface. A hybrid post that was created using artificial intelligence is non-dexterous to patients and clinicians, has high precision, less material-dependent errors, fewer manual errors, and is economical.

Conclusion:

Fracture resistance of endodontically treated teeth reinforced with hybrid post showed significant values when compared to that of prefabricated glass fiber posts, prefabricated threaded post and control teeth. Hybrid post involves less dentine removal after biomechanical preparation and greater resistance to fracture. Hence hybrid post can be first technique of choice rather than traditional techniques with proper knowledge and skill of the clinician.

Conflicts of Interest: Nil

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