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Original Research

Comparative evaluation of fracture resistance of endodontically treated teeth restored with glass fiber post and a novel prefabricated edelweiss post & core system –an in vitro study

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ABSTRACT

Background: The endodontically treated teeth with compromised crown structure for its restoration necessitates the construction of a post and core to deliver necessary support and retention for the final crown.
Aim: To assess and compare the fracture resistance and failure form of glass fiber post with composite core build-up and prefabricated single unit resin composite post &core.
Methodology: 40 human extracted mandibular premolars were split into two groups at random, administered root canal therapy, and then obturated with gutta-percha. Glass fibre post (TENAX®FiberTrans Coltene/Whaledent, USA) was cemented after the post space preparation in teeth under Group 1(n=20), and a separate composite core build-up was completed. In Group 2 (n=20) resin composite post and core single unit (Edelweiss post and core, Edelweiss dentistry products GmbH, Austria) were placed. Thermocycling (between 5 and 55°C, 30-second dwell period) was performed on all samples. The fracture resistance was tested in a Universal testing machine using a compressive load. The fracture force was measured in Newtons and a stereomicroscope was used to investigate failure patterns.
Statistical analysis: Independent T-Test
Results: A statistically significant difference amongst the two groups ($p<0.05$) was noted.
Conclusion: The prefabricated Edelweiss resin composite post and core single unit has greater fracture resistance than the post made of glass-reinforced fibre. The failure pattern observed in the Glass fiber post was a non-catastrophic core fracture, post debonding, post-fracture, and tooth fracture while in Edelweiss post and core single unit showed non-catastrophic core and tooth fractures. There was no post debonding or post-fracture in Edelweiss post and core single unit.

***Keywords:** Edelweiss post and core single unit; Fracture resistance; Failure mode; Glass fiber post.*

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INTRODUCTION

Endodontically treated teeth in many cases have compromised crown structure.[1] The common technique for restoring such teeth is to rehabilitate it with post and core followed by full crowns.[2] Prefabricated posts have become more popular among the posts because of their feasibility and shorter chairside times.[3] As a result of tooth-colored posts' elastic modulus being similar to dentin's, during physiological function, stress is distributed throughout the whole root canal.[4] These tooth-colored post have also improved esthetics especially when all-ceramic crowns have to be placed. Howbeit, the drawback of a resin composite core bonded to a fiber-reinforced post is that it takes more time to build the core at the chairside and that the bond of composite core material to post surface may fail cohesively.[4,5,6]

Accordingly, Edelweiss Dentistry (Austria) has created a prefabricated single unit tooth-colored post and core employing high density laser sintered composite material that has the elastic modulus akin to that of dentin to resolve this drawback of using a separate core. There is presently not much data available in the literature comparing these post systems with cores integrated as a single unit to post systems with separate cores and their impact on the fracture resistance of teeth following root canal treatments.

The primary aim of this study was to compare and evaluate the fracture resistance and failure mode of glass fiber posts (TENAX® Fiber TransColtène/ Whaledent, USA) with composite core build-ups and prefabricated single unit composite resin posts and cores (Edelweiss post and core, Edelweiss dentistry products GmbH, Austria).

MATERIALS AND METHODS

Kempegowda Institute of Medical Science, Institutional University Ethics Committee with registration number ECR/216/Inst/Kar/2013/RR-19 accepted this research protocol.

Preparation of specimens

Forty human permanent mandibular premolar teeth removed for orthodontic reasons were used for the study. The samples of extracted teeth were cleaned with a periodontal curette and kept in a liquid of 0.5% chloramine-T. The crown was cut into transverse sections using a double-sided diamond disc 2 mm above the cementoenamel junction (CEJ). The samples were then standardised to a minimal length of 14–15 mm and split into two groups.

Specimen Grouping

- GROUP1 (n=20)- Glass fiber post (TENAX® Fiber TransColtène/Whaledent, USA) and separate composite resin core build-up (Dual cure - Core• X™ Dentsply DeTrey GmbH, GERMANY)
- GROUP 2(n=20) -Resin composite post and core single unit (Edelweiss post and core, Edelweiss dentistry products GmbH • Austria).

All 40 samples underwent root canal treatments using ProTaper Gold files up to F3 size. The canals were then flushed with saline after being irrigated with 3% sodium hypochlorite and 17% EDTA. After that, the canals were obturated using a single cone obturation technique utilizing Protaper Gutta-Percha points-size 30 and AH Plus sealer, and they were restored to a depth of 3 mm with temporary material (Coltosol® F, Coltène/Whaledent AG, Switzerland). All specimens were submerged in 0.5% Chloramine T for 24 hours to allow the cement to fully cure. For the glass fiber post group, the obturation material was removed to a thickness of 9 mm using Peeso reamer #4. The manufacturer specified drill was used for group 2. The Edelweiss drill was 1.4mm wide at the apical tip and the length was 9mm.

The canals were then shaped with finishing drills for both groups. For the apical seal, 5 to 6mm of the gutta percha was retained apically. Following the post-space preparation, the canals were irrigated for 1 minute with 5 ml of a 17% EDTA solution, subsequently for 1 minute with 5 ml of a 3% NaOCl solution. Eventually 2ml saline was used for one minute to cease the irrigants activity and then dried with the paper point. The trial fit of both the groups of glass fiber post and Edelweiss post and the core single unit was checked radiographically (Figure 1 and Figure 2).

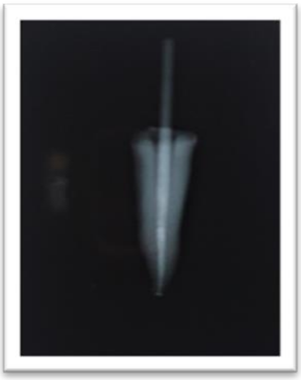

Fig 1: Radiographic image of fit of glass fiber post

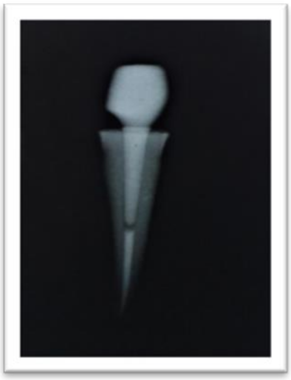

Fig 2: Radiographic image of fit of Edelweiss post

DeTrey® Conditioner 36, Dentsply DeTrey GmbH, Germany, was employed to etch the post space and remaining coronal structure for 20 seconds which later was completely rinsed with water. Prime & Bond® NTTM (Nano-Technology Dental Adhesive, Dentsply DeTrey GmbH, Germany) and self-cure activator (Dentsply DeTrey GmbH, Germany) were mixed and applied with a disposable brush or applicator tip. The post space and remaining coronal tooth surface was coated with the dual-cure adhesive for about 20 seconds prior to being light cured using Ultradent's Valo Ortho LED Curing light Unit 1000. Both the glass fiber post surface and the Edelweiss post surface were simultaneously coated with silane coupling agent (Ultradent Products, Inc. US) and Edelweiss veneer bond (Edelweiss dentistry products GmbH, Austria). Dry air was then applied to the post surface to give it a uniform glossy appearance. Dual cure restorative cement (Core•XTM Dentsply DeTrey GmbH, Germany) was coated onto the post surface and to the orifice of the post space preparation, remaining coronal tooth structure. Then, the post was inserted and secured into the final position and cured on all sides for 20 seconds.

All 20 samples of glass fiber posts had their cores built up using Dual cure highly filled composite resin (Core•XTM Dentsply DeTrey GmbH, GERMANY), and each sample's core width and length were uniformly standardised at 5.5mm and 5mm, respectively. To create a homogeneous 5mm core, any vulnerable points between the tooth samples and the core were filled using Dual cure composite resin (Core•XTM Dentsply DeTrey GmbH, GERMANY).

To imitate the effect of the periodontal ligament, the tooth samples were mounted on acrylic blocks using Polyvinyl-siloxane impression material. To simplify the process of retrieval of the tooth after the acrylic block has polymerized, a thin coat of glycerine was applied utilizing applicator tips onto the root surface of each sample. The tooth was put in a 2.1x2.1x2.7cm3 block of self-curing acrylic resin with its long axis vertical to the acrylic block's base and acrylic terminating 2mm below the CEJ. The roots were carefully retrieved from the polymerized acrylic resin. The tooth was then reinserted after siloxane impression material was put into the mould space. All 40 samples underwent manual thermocycling (serological water bath) with dwell times of 30 seconds for approximately 1000 cycles at 5°C and 55°C. Following thermocycling, the samples were evaluated for fracture resistance utilizing the Universal Testing Machine (Figure 3).

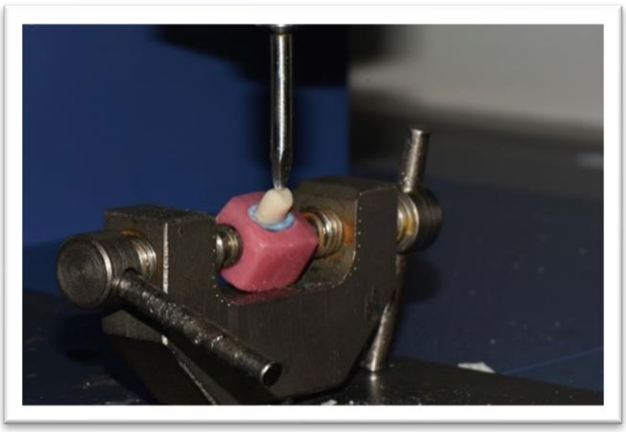

Figure 3: Fracture testing -universal testing machine

Figure 4: Types of failure viewed under stereomicroscope - Glass fiber post

Fig 5: Failure mode - edelweiss post and core single unit

The lingual occlusal line angle of the core was marked with a standard marking at a 135-degree horizontal angle, and continuous compressive pressures was exerted with a crosshead speed of 0.5 mm/min until fracture. The fracture force was measured in newtons. The method of failure of all specimens was viewed under a stereomicroscope at 20x magnification.

Statistical analysis

Data were evaluated using the statistical package SPSS19.0 (SPSS Inc. Chicago, IL) and the level of significance was set at $p < 0.05$. Descriptive statistics were used to find the mean and standard deviation of individual groups. An independent t-test was employed between the groups to discover the significance.

RESULTS

Analysis revealed a significant difference between the two groups ($p < 0.035$) by independent t-test. The glass fiber posts exhibited a mean failure load of 1089.234 ± 225.324N and Edelweiss resin composite post and core single unit with a mean of 1305.419 ± 327.689 N (Table 1).

Table 1: Comparison of fracture resistance between the two groups

Table 1 : COMPARISON OF FRACTURE RESISTANCE			
Group	Mean	SD	P VALUE(independent t-test)
Glass Fiber Post (Fracture resistance)	1089.234	225.324	0.035 (t=2.1801)*
Edelweiss post (Fracture resistance)	1305.419	327.689	

In the case of glass fiber posts, failure modes was evaluated. In the 20 samples, there were a total of 9 core fractures (45%), 6 post debondings, 3 post fractures, 1 tooth fracture, and 1 root fracture (5% each) i.e., non-catastrophic fracture constituting about 95% while Catastrophic fracture of 5%.

The case of Edelweiss resin composite post and core single unit showed a total core fracture of 17 among the 20samples (85%). The number of tooth fractures seen was 3 out of the total 20 samples (15%) subjected to fracture i.e., non-catastrophic fracture constituting about 100% while Catastrophic fractures were not seen in this group.

DISCUSSION

The glass fiber post consists pre-stretched silanized glass fibers that are strongly cross-linked and bonded together using a methacrylate or epoxy-polymer matrix with a high degree of conversion.[7,8,9] The Edelweiss post and core system is a laser sintered nanohybrid composite monobloc. The posts have a conical shape and avoid wedging effects. It is produced using the additive manufacturing (AM) technique of selective laser sintering (SLS).

In accordance with computer-aided design, the powdered material is applied layer by layer (CAD). The material is sintered using a laser, producing a homogeneous, inorganic, and highly glossy post surface that is then fused by sintering and thermal tempering (3000℃) dynamic composite core. A transparent post is linked to an opaque built-in core, giving the aesthetic property a distinctive appearance.[10] The translucency of the fiber-free post, supported by the lens design in the core, allows uninterrupted light transmission for complete polymerization of the luting cement resulting in a single monobloc between the adhesive layer and composite post. The manufacturer states that there is no chance of the post and core debonding since they are a homogeneous monoblock.[10]

When compared to a glass fibre post, the edelweiss composite post and core system demonstrated a high fracture resistance. The resin composite material, which is a nano-hybrid composite modified using a unique laser sintering and vitrification method to turn the composite into a single inorganic phase, may be the cause of the high fracture resistance, enhancing both its physical and mechanical properties.[10,11]

Anusavice et al recorded in their study that the maximum biting force is about 756N.[12,13] The maximum biting force suggested by Anusavice was substantially lower than the estimates for the glass-reinforced fiber post's fracture resistance. 12 Thus, even if the glass fiber post's fracture resistance is lower than that of the Edelweiss post and core combined, it may not have any clinical relevance in function.

Debonding of the posts is the common failure seen in fiber-reinforced composite posts which is seen between post-cement interface than intra-cemental or cementum -dentin interface. This is caused by the highly polymerized, industrially cured, extremely cross-linked epoxy resin used in glass fibre posts. It is therefore challenging to connect with methacrylate-based resin cement because relatively tiny amounts of free resin are only accessible to interact with the reactive chemical components that are present in resin lutes or composite resin cores. Debonding may also result from temperature fluctuations, dynamic functional loads, and changes in physical qualities like flexural strength and elastic modulus caused on by water sorption and expansion.[14,15] Post debonding was not observed in the edelweiss post and core system. The monobloc system produced in the case of Edelweiss post and core may be the explanation for the development of such a condition.

According to the research done by Asif et al., a full crown placed over a 2mm ferrule may alter how forces are distributed between the post and core complex and the root.[16] The test loads in this investigation were administered directly to the core, which was not fully restored with a crown. This was done to prevent any outside forces from strengthening the post and core foundation. The outcomes of this study may have been different if the entire crown above the core had been included.[15,17] This study's application of steadily rising static loads to samples that did not represent the sorts of loads found in the oral cavity was another shortcoming. The forces exerted on the teeth in the oral cavity would have likely been recreated in research with cyclic loading.[9,18,19,20] Additionally, since this was an in-vitro trial, it is possible that the material's performance in a clinical context would differ.

CONCLUSION

Within the parameters of this study, the Edelweiss resin composite post and core single unit demonstrated much greater fracture resistance than the Glass fiber post with a separate composite core build-up. When compared to Edelweiss composite resin post and core single unit, glass fiber post mostly demonstrated core fracture, post-fracture, post debonding, and tooth fracture. In the Edelweiss post and core single unit, no post-debonding nor post-fracture were seen.

Conflict of Interests: Nil

Source of funding: Nil

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