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EVALUATION OF FRACTURE RESISTANCE IN ENDODONTICALLY TREATED TEETH FOLLOWING PLACEMENT OF DIFFERENT INTRA-ORIFICE BARRIER MATERIALS (AN IN VITRO STUDY)

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ABSTRACT

BACKGROUND: Endodontically treated teeth (ETT) are potentially weaker than vital teeth against chewing forces and more prone to fracture.

AIM: To evaluate and compare the effect of three intra-orifice barriers on the fracture resistance (FR) of endodontically treated teeth.

MATERIAL AND METHODS: Fifty teeth divided into five groups according to the intraorifice barrier used: (n=10 each): Group I: Cention N, Group II: GC EverX Flow, Group III: GC Fuji LC 2 Gold Label, Group IV: (positive control group) no intra-orifice barrier was placed and Group V: Negative control group, root canal was instrumented and left empty without obturation. All subjects underwent FR test by universal testing machine.

RESULTS: The median FR values were 988.04 for Cention N, 938.35 for EverX Flow, 1241.19 for GC Fuji LC 2 Gold Label, 954.11 for positive control, and 835.26 for negative control. The range of FR values (minimum to maximum) for each group was as follows: Cention N (678.53 – 1227.96), EverX Flow (312.55 – 1406.96), GC Fuji LC 2 Gold Label (654.88 – 1440.34), Positive Control (756.04 – 1490.64), and Negative Control (769.04 – 1004.61). The Kruskal-Wallis H test yielded an H value of 9.365 with a p value of 0.053 indicating no statistically significant difference between the five groups.

CONCLUSION: Centon N and GC EverX Flow increased FR to a certain extent, but showed lower value compared to GC Fuji LC 2 Gold Label. Further studies are needed to support our findings.

KEY WORDS: Cention N, EverX Flow, GC Fuji LC 2 Gold Label, intra-orifice barrier, fracture resistance.

RUNNING TITLE: Assessing fracture resistance using intra-orifice barrier materials.

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INTRODUCTION

It is possible that endodontically treated teeth (ETT) are weaker and more likely to fracture than vital teeth when chewing forces are applied. In 11-20% of extracted ETT, vertical root fracture (VRF) have been reported. A VRF is a longitudinal fracture of a root that is parallel to its long axis (1). During access cavity preparation, root canal instrumentation and obturation; dentin is stressed by a momentary contact Amidst instruments and canals walls, resulting in microcracks, lines, and defects. Dentin mechanical properties are altered by chemical preparations, promoting the propagation of fatigue cracks and contributing to VRF susceptibility (2).

Pericervical dentin can be defined as the area approximately four mm above and six mm below the alveolar ridge. This structure is responsible for the transmission of occlusal forces to the root (3). Therefore, to reduce the chances of fracture in teeth that have undergone endodontic treatment, it is important to strengthen them with materials that can provide the required strength (4).

Intraorifice barriers (IOBs) were first developed by Roghanizad and Jones (5) to prevent microleakage. By replacement of 3 mm of gutta-percha with restorative material at the root canal orifice. Moreover, studies have advocated the use of restorative materials for endodontically treated teeth which have a similar or higher elastic modulus than the tooth can be proposed for providing stiffness against forces that generate root fracture (6-8).

A new resin-based material, called Cention N, known as alkasite, was introduced as a new material capable of neutralizing acids. Alkasite consists of alkacid fillers, including fluoride, calcium, and hydroxide ions (9). Dense polymer networks in the material are responsible for higher strength and is designed for simple and convenient bulk application. (10).

The use of GC EverX Flow; Fiber-reinforced flowable composite is also recommended as IOB, especially in large cavities with high stress-bearing areas. This biomimetic technique allows for more stress distribution and decrease in polymerization shrinkage (11).

A resin modified glass ionomer cement (RMGIC) made in the late 1980s, GC Fuji LC 2 Gold Label contains some methacrylate components present in resin composites. Due to its high modulus of elasticity and flexural strength, it can endure lots of stress before it transmits the load to the root. By creating a chemical bond with root dentin, it presents greater strength to the interface between dentin and cement (12).

The aim of this study was to assess and compare the impact of three IOBs on the FR of ETT.

The null hypothesis was that there would be no significant difference in FR among the different groups.

MATERIALS AND METHODS

Ethical considerations

The study was conducted after receiving the approval of the ethical committee at Faculty of Dentistry, Alexandria University, Egypt (0781-1012023).

I. Teeth selection

Inclusion Criteria: 50 freshly extracted sound single rooted lower permanent premolars with roots showing minimal curvature and with mature apices.

Exclusion Criteria: Teeth with fracture, craze lines, internal or external root resorption, extremely curved roots and previously root canal treated teeth.

To standardize the teeth selected for this study, a strict set of inclusion and exclusion criteria were applied. Additionally, only those with mesio-distal dimensions ranging from 6.5 to 7.5 mm and bucco-lingual dimensions between 7 and 8.5 mm were included. The dimensions were measured using a calibrated digital caliper, with a tolerance of ± 0.1 mm to ensure precision. To further control for variability, all teeth were cleaned thoroughly using ultrasonic scaling to remove any residual calculus or debris. Following cleaning, the teeth were uniformly stored in distilled water solution at room temperature to prevent dehydration or decay. Throughout the study, all handling and storage conditions were kept consistent.

II. Specimen Preparation

Specimens were standardised by reducing the teeth to a length of 14 mm from the coronal aspect. A size 10 K-type file was inserted into the canal until it became visible at the apical foramen. The working length was set 1 mm short.

III. Canal Preparation

Root canals were prepared using a hand file up to a #15 K-file, followed by the rotary Protaper Gold system (Dentsply Maillefer, Ballaigues, Switzerland), adhering to the manufacturer's instructions and employing a crown-down technique. Shaping and finishing files were systematically used until reaching F4 (0.40 / .06v). During the instrumentation, the canals were irrigated with 5 ml of 2.5% sodium hypochlorite after each file change, and a final irrigation was performed with 5 ml of 17% EDTA solution. Finally, the canals were rinsed with 10 ml of distilled water. (13).

IV. Canal Obturation

Canal obturation was performed by lateral condensation technique and the sealer used was AH plus sealer (Dentsply Caulk, Milford, DE) that was mixed according to manufacturer instructions, A heated plugger was utilized to remove the coronal 3 mm of root canal obturation in all groups. except in the negative control group. Samples were then stored in an incubator at 37°C for 1 week for a complete sealer set (14).

V. Placement of Intra Orifice Barriers

Obturated specimens were divided into the following groups immediately after the 1-week incubation process, with respect to the IOB material placed over the root canal fillings.

Group I: Cention N (n = 10), was mixed by adding one drop of liquid to one scoop of powder, corresponding to a powder/liquid weight ratio of 4.6 to 1. It was then applied into the canal orifices and light-cured for 20 seconds.

Group II: GC EverX Flow Fiber-reinforced flowable composite (n = 10), the root canal orifices were etched with 37% phosphoric acid for 15-20 seconds. Then the surface was rinsed with water and and air-dried. Subsequently, the adhesive was applied to the canal orifices and was light-cured for 10 seconds. Finally, GC EverX Flow was placed into the root canal orifice and light-cured for 20 seconds.

Group III: GC Fuji LC 2 Gold Label, (n = 10), the standard powder-to-liquid ratio 3.2 g/1 g (1 level scoop of powder to 2 drops of liquid) was mixed according to the manufacturer's instructions. The barrier material was then placed into the root canal orifices and light-cured for 20 seconds.

Group IV: (Positive Control group) no intra-orifice barrier was placed (n = 10)

Group V: Negative control group, root canal was instrumented and left empty without obturation (n = 10).

VI. Simulation of the periodontal ligament and embedding of the specimens

The root was covered with 0.2 mm thick aluminum foil, adapted evenly to the whole area of the tooth root for each sample. An elastic band was marked 2.0 mm beneath the cut surface to make sure that the teeth were not be submerged in acrylic (15). Following that, cold cure acrylic resin was applied to the container and cured in a water bath at room temperature. After removing the specimens from the acrylic blocks, the foil was removed, and a suitable amount of auto-mix silicone impression material (Empress XT, 3 M ESPE) was delivered through the mixing tip into the acrylic resin block with the dispenser gun. In the end, the acrylic block was refilled with the tooth specimen.

VII. Fracture resistance testing of teeth

A stainless-steel loading fixture with a diameter of 5mm round tip from the universal testing machine was aligned directly above the canal opening on top of the intra-orifice barrier material, and a compressive force was exerted at a crosshead speed of 1 mm/min until a fracture took place. The force needed to break each specimen was recorded in Newtons (N). (16).

Statistical analysis

Normality of FR was checked using Shapiro Wilk test and Q-Q plots. Normal distribution was confirmed thus data was presented using mean and standard deviation (SD) in addition to median, minimum and maximum values. Difference in FR was analyzed using One Way ANOVA test followed by Tukey's HSD post hoc test with Bonferroni Correction. All tests were two tailed and the significance level was set at p value<0.05. Data was analyzed using GraphPad Prism version 10.0.0 for Windows, GraphPad Software, Boston, Massachusetts, USA.

RESULTS

The study compared the FR of five different groups: Cention N, EverX Flow, GC Fuji LC 2 Gold Label, Positive Control, and Negative Control. The median FR values were 988.04 for Cention N, 938.35 for EverX Flow, 1241.19 for GC Fuji LC 2 Gold Label, 954.11 for Positive Control, and 835.26 for Negative Control. The range of FR values (minimum to maximum) for each group was as follows: Cention N (678.53 – 1227.96), EverX Flow (312.55 – 1406.96), GC Fuji LC 2 Gold Label (654.88 – 1440.34), Positive Control (756.04 – 1490.64), and Negative Control (769.04 – 1004.61). The Kruskal-Wallis H test yielded an H value of 9.365 with a p value of 0.053 indicating no statistically significant difference between the five groups (Table 1).

Table 1: Comparison of fracture resistance among the study groups

	Cention N (n=10)	**EverX Flow (n=10)**	**GC Fuji LC 2 Gold Label (n=10)**	**Positive Control (n=10)**	**Negative Control (n=10)**
Mean ±SD	978.24 ±161.66	996.42 ±347.21	1158.98 ±232.20	960.65 ±217.62	856.37 ±82.95
Median	988.04	938.35	1241.19	954.11	835.26
Min – Max	678.53 – 1227.96	312.55 – 1406.96	654.88 – 1440.34	756.04 – 1490.64	769.04 – 1004.61
H Test (*p* value)	9.365 (0.053)				

H test: Kruskal Wallis Test, SD: standard deviation, Min: Minimum, Max: Maximum

DISCUSSION

Different factors, such as root canal morphology, dentin thickness, canal shape, and the size and curvature of the external root, should be considered when assessing the fracture susceptibility of teeth that have undergone endodontic treatment. Therefore, it is crucial to ensure that there is enough remaining dentin to provide adequate support. Hence, it is essential to restore teeth subsequent to root canal treatment in order to avoid tooth fracture. (17). IOB are known to support ETT and reduce chance of fracture (7). In this context, the current study evaluated the FR properties of Cention N and EverX Flow compared to GC Fuji LC 2 Gold Label.

Results showed that GC Fuji LC 2 Gold Label showed the highest FR, followed by EverX Flow and Cention N, while the lowest FR was found in control groups. The comparison between tested groups showed no significant differences, which indicated that the used IOB displayed comparable potentials in increasing FR of ETT.

The increased FR resulting from the use of different IOBs maybe due to composition, bonding, mechanical, design, and reinforcement properties (18,19). In Cention N group, the enhanced FR could be attributed to the size of the inorganic filler nanoparticles, rendering more appropriate option for therapeutic treatments. Furthermore, it has been discovered that Cention N has physio-mechanical qualities superior to those of resin-based composites and exhibits a stronger behavior than glass ionomer cements (GICs). This confirms that Cention N is suitable for the long-term repair of decaying or broken teeth (20).

Our results agreed with Adsul et al. (21), who found that Cention N had high flexural strength and microhardness. The results also agreed with Sadananda et al. (18), and Mazumdar et al. (22), who showed that Cention N had the highest microhardness compared to CIG, RMGIC, and Amalgam silver.

Results also showed that EverX Flow exhibited higher FR than Cention N. In addition, GC Fuji LC 2 Gold Label displayed the highest FR compared to Cention N and EverX Flow. The increased FR of EverX Flow could be attributed to the presence of short fibers incorporated in the matrix that had significantly improved the material's ability to resist crack propagation and lowered the stress intensity at the tip of the crack, and its propagation in an unstable manner and increased fracture toughness (23). Our results are in accordance to Selvaraj et al. (24) reported that EverX Flow was useful as an intra-orifice barrier and in reinforcing roots.

In our current study, GC Fuji LC 2 Gold Label exhibited the highest FR with no significant difference compared to other tested IOB materials groups. This is in agreement with Gupta et al. (25), who reported that FR of RMGIC was higher than fiber reinforced composite. This could be attributed to its high flexural strength and modulus of elasticity (ranging from 10 to 14 GPa), which closely resemble those of dentin. (26). In consequence, the material can endure considerable stress before passing the load onto the root. (27). Furthermore, it establishes a chemical bond with the dentinal surface, increasing the strength at the dentin-cement interface. (28). These characteristics may have contributed to GC Fuji LC 2 Gold Label being the most fracture-resistant material evaluated in this study.Consequently, the null hypothesis was accepted as there was no significant difference regarding FR between the different IOB groups.

CONCLUSION

Considering the limitations of this in vitro study, the following conclusions can be made: The presence of intra-orifice barriers contributes to increased fracture resistance and enhances the reinforcement of endodontically treated teeth. Cention N, Ever X Flow and GC Fuji LC 2 Gold Label can be used as IOBs with promising FR in ETT.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interests.

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