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Evaluation of the Effect of Different Intraorifice Barrier Materials on Fracture Resistance of Endodontically Treated Teeth (*An in vitro study*)

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Abstract

Background: Endodontic failure can be caused by the teeth's lack of strength after endodontic treatment, which leads to post-endodontic vertical root fracture. The intra-orifice barrier is a trustworthy reinforcement method for endodontically treated teeth as a result. Aim: To determine how three distinct restorative materials (Ever X Flow, Cention forte, and Bio-C sealer ION) assist in resisting fracture endodontically treated teeth using a universal testing machine. Materials and Method: This study used fifty human mandibular premolars to investigate the effect of different intraorifice barrier cavity fillings on fracture resistance. The roots were prepared and obturated with gutta-percha and AH Plus sealer. The coronal 3-mm of gutta-percha was removed to receive the intraorifice materials, except for Group I which had a fully obturated root canal without intraorifice barrier cavity preparation. The roots were then divided into different groups based on the type of intraorifice barrier cavity filling used. All groups underwent thermo-cycling aging before fracture resistance analysis was performed. Results: Generally, Fracture resistance of endodontically treated teeth was significantly affected by the type of intraorifice barrier at($p<0.05$); the results indicated that Group II showed the least fracture strength among all groups, While Group III (Ever X Flow) showed maximum fracture resistance followed by Group IV (Cention forte), Group I (positive control) and finally Group V (Bio-C sealer ION). Conclusion: Within the limitations of the current investigation, using Ever X Flow, Cention forte, and Bio-C sealer ION as an intra-orifice barrier may help strengthen teeth that have undergone endodontic treatment. When compared to the positive control group ((Fully obturated root canal without intraorifice barrier cavity preparation), the Bio-C sealer ION did not significantly increase the fracture resistance of endodontically treated roots.

Introduction:

Endodontically treated teeth have collapsed architecture with a reduced amount of tooth left which causes the teeth to become less fracture resistant (1). The strength of endodontically treated teeth is obviously influenced by the amount of tooth structure that remains following canal preparation. Overinstrumentation, post-endodontic dentin dehydration, and excessive pressure during obturation are all variables that can lead to root fracture. In addition to occlusal strain, each of these factors may raise the risk of a root fracture. Moreover, the combination of intracanal irrigants and drugs may affect the physical and mechanical properties of the root dentin, which may lead to the failure or fracture of teeth that have received endodontic treatment. Obturation materials are thought to be essential for the stability of teeth that have undergone endodontic treatment. When combined with a sealer, gutta-percha is one of the most regularly used root canal filler materials; however, because it has a lower elastic modulus than dentin, it has little effect on strengthening roots during root canal therapy.(2).

The main goals of post-endodontic restoration are to increase root fracture resistance and create an impermeable hermetic seal (3). It had been recommended to use intraorifice barrier (IB) restorative materials for endodontically treated teeth largely to avoid bacterial contamination (4). It would be helpful to place material over the coronal gutta percha to serve as a barrier against coronal microleakage in order to lessen leakage and improve treatment outcomes (5).

The placement of intraorifice barrier materials with coronal restoration for endodontically treated teeth that have an elastic modulus similar to or higher than the tooth can provide stiffness against forces that generate root fracture and can bond to radicular dentin to further reinforce the peri-cervical dentin and prevent coronal microleakage (3)

The procedure consists of removing a portion of the coronal gutta-percha and filling the space with a restorative substance (IB). Since some studies tested various intraorifice barrier depths, ranging from 1 mm to 4 mm, and found that results were often better when it was put at (3 mm) depth, the depth of the barrier appears to be a key component in preventing microleakage (6).

Intraorifice barrier materials should have the following qualities: bonds to the tooth structure, seal against microleakage, are easily manipulated, can be distinguished from the natural tooth structure, and do not interfere with the final restoration (7).

In order to replicate dentin's capacity for stress absorption, short fiber-reinforced composite (SFRC) was first offered to the market in 2013. For the restoration of both vital and non-vital teeth, the SFRC material is designed to be used as a bulk basis in high stress locations. It has the capacity to equal the fracture resistance of dentin and is simple to employ in increments of 4 mm. Short E-glass fibers and particle fillers, primarily barium glass, are used as fillers in the SFRC, which is made up of a resin matrix that contains Bis-MEPP 15–25%, TEGDMA 1–10%, and UDMA 1–10%. Fibers are 140 mm on average in diameter. 70% of the overall weight is made up of filler, and fibers (w/w) are 25%. According to the manufacturer (GC Corporation Tokyo, Japan) (8).

Recently, Alkasite materials are a novel family of resin-based ion-releasing compounds that were introduced To prevent demineralization of enamel and dentine when exposed to lactic acid for an extended period of time, Cention, a bulk-fill restorative material with photoinitiators and chemical catalysts that enable a dual cure polymerization mechanism, releases Ca^{2+}, F, and PO_4 ions in neutral and acidic conditions and forms apatite on its surface. The first material that was hand-mixed was Cention N (Ivoclar Vivadent), whereas Cention forte (Ivoclar Vivadent) is a capsulated variant. The ingredients in Cention forte are powders of reactive SiO_2-CaO-CaF_2-Na_2O glass, inert barium alumino-borosilicate glass, ytterbium fluoride, and aromatic aliphatic UDMA, as well as liquids of UDMA, DCP, and PEG-400-DMA. The initiator system consists of hydroperoxide, ivocerin, and acyl phosphine oxide, Filler content: is 58–59 vol% according to the manufacturer (Ivoclar Viva-dent AG9494/Liechtenestein (9).

The best qualities of bioceramics in endodontics include their biocompatibility, osteoinductive capacity, ability to achieve an excellent hermetic seal due to their capacity to hygroscopically expand, ability to chemically bond with the tooth structure, antibacterial properties, and good radiopacity (6).

However, Premixed bioceramics were introduced as a result of recent advancements in bioceramics, which improved their handling characteristics. These pre-mixed bioceramics are all hydrophilic, resulting in a more homogenous mixture and a consistency closer to putty that only sets in the right environment, giving sealers the advantage of consistent consistency and lack of waste. Calcium silicates, calcium aluminate, calcium oxide, zirconium oxide, iron oxide, silicon dioxide, and dispersion agents are among the constituents in bio-c sealer, depending on the manufacturer (Angelus, Londrna, PR, Brazil) (10).

Therefore, This study aims to evaluate the effect of (Ever X Flow, Cention forte, and Bio-C sealer ION) as intraorifice barriers (IB) for endodontically treated teeth on fracture resistance. The null hypothesis was (1). No significant difference in the fracture resistance of three intraorifice barrier materials in endodontically treated roots.

Materials and Methods:

Sample preparation: For this study, fifty single-rooted, healthy human mandibular premolar teeth that were extracted for orthodontic therapy had approximately identical sizes. Using a periodontal scaler, soft tissue, and calculus were mechanically removed from the root surfaces. The teeth were then kept at room temperature in a 0.1% thymol solution until usage (5).

The teeth are decoronated with a diamond saw bur while being cooled by water, achieving a root length of 15 ± 0.5mm by digital vernia to standardize samples' length as shown in Fig. (1). A barbed broach was used to reach the root canals and remove the pulp tissue. A#10 K-file from (Rogin Dental, China) was used, and the working length was measured using a stereomicroscope. This length was 1 mm less than the length of the file when it was visible at the apical foramen(11)

Make consistent measurements of the mesiodistal and buccolingual diameters of the coronal plane of the root canal and the root using a digital caliper (SPAC systems, Pune, Maharashtra, India). The average buccolingual and mesiodistal diameters of the coronal plane were used to reject roots that presented with a deviation of more than 10% from those values. The coronal plane of the roots canal was chosen to be approximately similar in buccolingual (BL) and mesiodistal (MD) dimensions (3.2 ± 0.2 and 1.6 ± 0.2 mm, respectively), and the coronal plane of the roots was chosen to be approximately similar in buccolingual (BL) and mesiodistal (MD) dimensions (7.5 ± 0.5 mm and 4.5 ± 0.5 mm, respectively) (5,11,12).

Each root was marked (3±0.5 mm) apical to the coronal end with an indelible pen and connected to the vertical arm of the surveyor in a way that the long axis of the tooth parallel to the arm via sticky wax and mounted in a Polyvinylchloride (PVC) retention tube, with a diameter of two centimeters and height of two centimeters. Each tube was filled with polyvinyl siloxane impression material mixed according to the manufacturer's instructions, so each root had been positioned at the center of the PVC tube, with the long axis of the root parallel to the sides of the PVC tube, which was filled with impression material extended 3mm below the root coronal end. The root sample was maintained in position for 10 minutes to give time for the impression material to be completely set in order to separate the surveyor arm from the tooth without distortion in the position (13).

Utilizing the crown-down method, the root canal instrumentation process was carried out using a ProTaper Universal rotary file system (Rogin dental, China) mounted on an E-Connect S endomotor (Eighteeth, Medical) at 250 rpm and 300 Ncm, respectively, in sequential order from SX, S1, S2, F1, F2, and F3 files, in accordance with the manufacturer's recommendations (14).

The irrigation procedure: was performed with 2 ml of 5.25% sodium hypochlorite (NaOCl) (AQUA Medical, Istanbul, Turkey) solution in each file change. Finally, the root canals were rinsed with 1mL of normal saline followed by (5mL) of 17% EDTA (Prime Dental Products, Mumbai, India) for 1min to remove the smear layer and finally rinsed with (5mL) of normal saline. The irrigation process was performed using a side vent disposable irrigation needle gauge 27(11,15).

After the root canals were dried using F3 paper points, the Obturation process was carried out using single cone equivalent gutta-percha (Rogin dental, China) and AH Plus Sealer (De Trey-Dentsply, Konstanz, Germany) mixed in accordance with manufacturer specifications. Glass ionomer cement (White Cimpat; Septodont, São Paulo, SP, Brazil) was used to seal the root canal openings. The specimens were preserved for 24 hours at 100% humidity and 37°C, as seen in Fig. (2). (11,16).

Intra-orifice barrier (IB) Cavity Preparation: The cement material was removed, all experimental groups, with the exception of the positive control group, had the coronal 3 mm of the root canal filling material removed. Post space preparation drills (peeso reamer, size #4, width 1.3 mm) were used to create the intra-orifice barrier cavity to a specified depth of 3 mm. The drill was utilized with a low-speed handpiece (Kavo Ind. Com. Ltda., Joinville, SC, Brazil) at 15,000 to 20,000 rpm, and as illustrated in Fig. (3), a stopper was positioned 3 mm from the tips and the depth of the intra-orifice barrier cavity was confirmed with the aid of William's periodontal probe and periapical X-ray. (12,16).

This space was then scrubbed and cleaned from any sealer or gutta-percha remnants with a cotton pellet soaked in 70% ethanol. Prepared orifice cavities were flushed with 1ml of 17% EDTA solution followed by a final rinse with 1ml saline and gently air dried (17).

Grouping of the specimens: Fifty prepared roots were selected randomly for fracture resistance evaluation and distributed randomly into: (n = 10).

Group I: Positive control (Fully obturated root canal without intraorifice barrier cavity preparation).
Group II: Negative control(Obturated root canal with intraorifice barrier cavity prepared but not filled).
Group III: The Intraorifice barrier cavity filled with short fiber-reinforced flowable composite (EverX FLOW, GC Corp).
Group IV: The Intraorifice barrier cavity filled with Cention forte (Ivoclar Vivadent).
Group V: The Intraorifice barrier cavity filled with Bio-c sealer ion (Angelus).

Restorative application: The intraorifice materials will be inserted in the coronal 3 mm prepared space according to manufacture as follows:

Sort fiber-reinforced flowable composite (EverX FLOW, GC Corp): A one-step self-etch adhesive, G-Premio Bond (Adhesive system, consist of4-MET, 10-MDP, MDTP, phosphoric acid ester monomer) (GC Corp, Tokyo, Japan), was applied, and cavities were then dried for 5 seconds under maximum air pressure and light-cured for 10 seconds. Fiber-reinforced composite (EverX FLOW, GC Corp) was placed as one layer (3mm) and light cured for 40 seconds with a light curing unit (LED cordless 10 W APOZA Enterprise Co., Ltd.Taiwan) at 2000 mW/cm2 light intensity.

Cention forte (Ivoclar Vivadent): Just apply Cention Primer to the prepared cavity and scrub the primer in. Open the Cention Forte capsule, combine the ingredients for the 15-second band, and then fill the cavity with the mixture. After the material has solidified, appropriate tungsten carbide burs can be used to complete it.

Bio-c sealer ion (Angelus): This material is ready to use formula in injectable syringes; NO MIXING.

Following the insertion of intraorifice barrier materials, all specimens were kept in an incubator for one week at 37°C and 100% humidity (3).

Artificial aging (Thermo-cycling): Thermo-cycling aging was carried out at Ankara University/ Faculty of Dentistry. All specimens were removed from the mold. After the specimens had been gauze-wrapped, they were put in a small, porous packaging with the number of relevant groups written on it. Next, all small porous packages were placed in a single giant package and transferred to the SD Mechatronik thermo-cycler. All specimens were thermocycled in distilled water for 1000 cycles (5–55°C) with a dwell time of 30 s and a draining time of 10 s between cycles (18).

Fracture resistance test:

A: Mounting of specimens for fracture resistance test: Preparing the special metal mold has the same dimensions as the root specimen plus two millimeters from all directions in order to provide standardized space representing the periodontal space. First, self-curing acrylic resin is mixed and poured into a special mold painted with a separating medium, After complete polymerization the resin block is removed from the metal mold. Ultimately, using Light Body silicone-based impression material combined with an activator (Speedex Light Body, Coltene/Whaledent Switzerland), a standardized silicone layer simulating the periodontal ligament was created. The teeth were then inserted into the silicon material, with the resin base centered with the dental surveyor arm, as shown in Fig.(4) (12).

B: Testing of specimens for fracture resistance test: As illustrated in Fig. (5), the strength test was conducted at a constant crosshead speed of 1 mm/min using a steel spherical tip with a diameter of 2 mm (perpendicular to the long axis of the tooth) on a universal testing machine (Gester International Co., Ltd.; China). Each specimen's canal opening was oriented with the loading segment's spherical tip in the middle. The force was measured in Newtons (N) at the moment of the fracture (19).

C: Failure mode analysis: To identify the failure mode of the specimens following the fracture resistance test, the de-bonded adhesion surface of each sample was examined using a stereomicroscope at 30x magnification as shown in Fig. (6) and classified failure mode according to the following descriptions (20):

- Mode I: Adhesive failure at the interface between the tooth and the restoration of the Intra orifice barrier.
- Mode II: Cohesive failure involving the restoration of Intra orifice barrier.
- Mode III:. Mixed adhesive and cohesive failure.

Statistical analysis: The data for this study were collected, tabulated, and statically analyzed using a compatible personal computer with a statistical package for social. science IBM SPSS (SPSS for Windows, IBM Corp., Version 26) for statistical analysis. The normality of data distributions and homogeneity of variance tests were assessed with Kolmogorov-Smirnov and Shapiro-Wilk at the significance level of ($P \leq 0.05$). Since the data obtained are not normally distributed, Variance analysis was performed with the Kruskal-Wallis test using a K-independent sample, and the Independent-Samples Kruskal-Wallis Test was performed to compare significance.

Results:

Fracture resistance analysis: The mean force required for a vertical fracture to occur in all five groups can be arranged in such that Ever x flow > Cention forte > Positive Control > Bio-C sealer > Negative control, as represented in Table (1) and Fig. (7).

The Kruskal-Wallis test for fracture resistance (Newton) of each group was statistically analyzed as represented in Table (2). The findings indicated there was a highly significant difference between among groups at (P≤ 0.05). The roots with Ever x flow exhibited the highest amount of force required to fracture the root while the negative control group showed the least amount of force required to fracture the root.

In addition, comparisons between the groups were statistically analyzed using **the** Independent-Samples Kruskal-Wallis Test as represented in Table (3). The findings indicated there was a significant difference between Ever x flow and the positive control group at (p=0.008) and a highly significant difference between Ever x flow and Bio-C sealer at (P =.000). No significant difference between the Ever x flow and Cention forte. A significant difference between the Cention forte and Bio-C sealer and the control groups, but no significant difference between the Bio-C sealer and positive control group at (P =.326). Mode of failure analysis: The modes of failure for intraorifice barrier materials to dentin of endodontic teeth as shown in Table (4) and Fig. (8). Regarding failure mode, the highest to the lowest rates of adhesive failure (mode I) of fracture were observed in Groups III (Ever x flow), IV(Centeno forte), and V(Bio C sealer) respectively. The highest to the lowest rates of cohesive failure (mode II) of fracture were observed in Groups V(Bio C sealer), III (Ever x flow), IV(Centeno forte), respectively. The highest to the lowest rates of mixed failure (mode III) of fracture were observed in Groups IV(Centeno forte), III (Ever x flow), and V(Bio C sealer), respectively. However, significant differences were found among the study groups in terms of fracture modes at (***p***<0.05).

Discussion:

The current study aimed to compare the force required to fracture roots with various materials (Ever x flow, Cention forte, and Bio-c sealer ion) functioning as intra-orifice barriers. According to the null hypothesis, there wouldn't be any discernible differences between the groups in the forces required to shatter roots. The null hypothesis was disproved since our results showed that these groups differed significantly from one another. The ever-x flow (short fiber-reinforced composite) (SFRC) therefore showed a much greater fracture resistance rating in comparison to the control group and other IB groups built of other materials. The variances in restorative material types and material component qualities could be the cause of the discrepancies.

Short fiber-reinforced composites (SFRCs) showed higher fracture resistance than the control group and other IB groups, according to the current study. Inorganic filler particles and short or nanofibers embedded in a resin matrix make up dental SFRCs. The new experimental SFRC showed higher fracture toughness and flexural strength compared to traditional particle filler resin composites. The reinforcing effect of fiber fillers is based on stress transfer from the polymer matrix to the fibers(21-24). These findings in line with Garoushi et al., which found that short fiber fillers had a preventative effect on crack development and improved fracture resistance(23). In a different study by Atalay et al., the fracture resistance of composite resin was compared between reinforced and unreinforced composites, and it was discovered that fiber reinforcing increased that resistance (25). The fiber length exceeds the critical fiber length, which is a function of stress transfer from the matrix to the fibers and each fiber acting as a crack stopper to inhibit the spread of cracks. It is also connected to the fiber's adhesion to the polymer matrix. (26,27). The behavior of SFRC shrinking in relation to filler loading was reported by Kumar and Sarthaj. Greater depth of cure is associated with increased filler content. The volume of the resin matrix for polymerization is subsequently decreased and hardness is increased with an increase in filler content. Polymerization shrinkage would be decreased with a higher filler concentration. (28,29). In contrast, this outcome doesn't agree with According to Miletic et al., glass fiber fillers did not affect the volumetric shrinkage of SFRC in the measuring setup, and it was comparable to or less than evaluated standard PFC resins (30). This is consistent with the findings of Al Sunbul et al.'s investigation on the shrinkage stress of eighteen commercially accessible composite resins (29). According to their report, SFRC had a value of 5.16 MPa, which was comparable to or lower than several of the bulk-fill and standard PFC resins evaluated. Polymerization shrinkage stress values ranged from 3.94 to 10.45 MPa. (29,30).

Furthermore, the homogeneous distribution of fibers within the resin was also noted, suggesting an improvement in reinforcing efficiency in all directions. Conversely, non-uniform fiber distribution can deteriorate the mechanism of load transfer between the fibers and the resin, thereby affecting the mechanical performance. (31).

According to the result of the present study resin-based ion-releasing alkasite materials (Cention forte) have a mean of fracture resistance less than ever x flow (SFRC) but no significant difference. These results are related to their composition and polymerization kinetics. Alkasite material, which exhibited the highest flexural and compressive strengths, can be attributed to having a high polymer network density and degree of polymerization throughout the entirety of the restoration (32).

This contradicts the findings of Navarro et al. (2019) and Seker et al. (2019), who found that Centon's bond strength values were either similar to or marginally greater than those of the composite group. These variances may also be attributable to compositional variations. Because it is hydrophilic, the PEG-400 DMA in the liquid portion of the Cention N may contribute to the enhanced bond strength (33-39).

While the bioceramic sealer (Bio-c sealer ion) group did not increase the force required to improve fracture resistance fracture of endodontic teeth when used as intra orfice barrier compared to the positive control groups, that could be explained as related to the sealer's physical and chemical properties(40-42).

Another is how alkaline materials affect the radicular dentin's mechanical characteristics. The dentine collagen network or the bonds between collagen and hydroxyapatite crystals may become denatured in an alkaline environment. Since it's been suggested that increased synthesis of some matrix metalloproteases (MMP-2, MMP-14) may aid in the breakdown of type I collagen in dentine, there may be a higher risk of root fractures (43,44)

In line with the findings of Ozyurek and Turker's investigation, the AH 26 epoxy resin-based sealer exhibited the highest level of fracture resistance across all tested periods when compared to calcium silicate-based sealers. These variations were not statistically significant, though. Contrary to Özyürek et al. (2019), which found no appreciable differences between AH 26 and BioRoot RCS, there were more voids in root canals sealed with the calcium silicate-based sealer (BioRoot RCS/GP) than with the epoxy-resin-based sealer (AH Plus)/GP (45).

Comparing EverX flow to other forms of resin composite, it had statistically the highest fracture resistance and flexural strength. EverX flow's outstanding performance may be attributed to its distinctive structure, which includes E-glass fiber fillers that are roughly equivalent to or slightly longer than the crucial fiber length. This short, randomly oriented fiber, together with the low density of the polymer matrix, facilitates the transfer of stresses from the matrix to the fibers and boosts the restoration's resistance to fracture. The latter gives a decreased polymerization shrinkage, which raises toughness and impact strength as a result(46,47,48).

The strength of the composite is improved by good adhesion with few voids, which is enhanced by suitable fiber length and proper adhesion between the fiber and the polymer matrix. Additionally, because of their greater dentine-like fracture resistance, short fiber-reinforced composites can respond more naturally(49-51).

According to the result of the present study resin-based ion-releasing alkasite materials (Cention forte) have a mean of fracture resistance less than ever x flow (SFRC) but no significant difference. also, Mode of failure, with rates of mode II (cohesive failure), mode III (mixed failure), and mode I (adhesive failure), respectively, ranging from the highest to the lowest no significant difference with ever x flow (SFRC). These results are related to their composition and polymerization kinetics.

Resin-based bioactive and remineralizing restorative materials are becoming more and more popular as a way to increase the longevity of bonded restorations. Alkaline glass, like alkasite materials, has a weight percentage of roughly 24.6%, which is what releases phosphate, calcium, and fluoride ions—all of which are critical for tooth remineralization. (52,53).

While the bioceramic sealer (Bio-c sealer ion) group did not increase the force required to improve fracture resistance of endodontic teeth when used as intraorfice barrier compared to the positive control groups and show only the mode II (cohesive failure) without mode I (adhesive failure). It might be described as being connected to the biomineralization property of the sealer. At the calcium silicate/dentin interaction, calcium silicate creates a structure like a tag(54,55).

Conclusion:

Endodontically treated teeth with an intraorifice barrier are more fracturally resistant. The kind of intraorifice barrier that is employed influences the root's resistance to breaking. Ever X flow and Cention forte had the highest levels of fracture resistance in a study, however Bio C sealer did not offer adequate root reinforcement. Different groups had different fracture processes; Ever X flow and Cention forte showed the highest adhesive failure, whereas Bio C sealer showed the highest cohesive failure. The greatest rate of mixed failure was observed in cent forte. Overall, the study indicates that obturated roots can be supported and the danger of postendodontic root fractures can be decreased by using short fiber-reinforced flowable resin composite barriers. To validate these results, however, more laboratory studies using various materials and clinical trials are required.

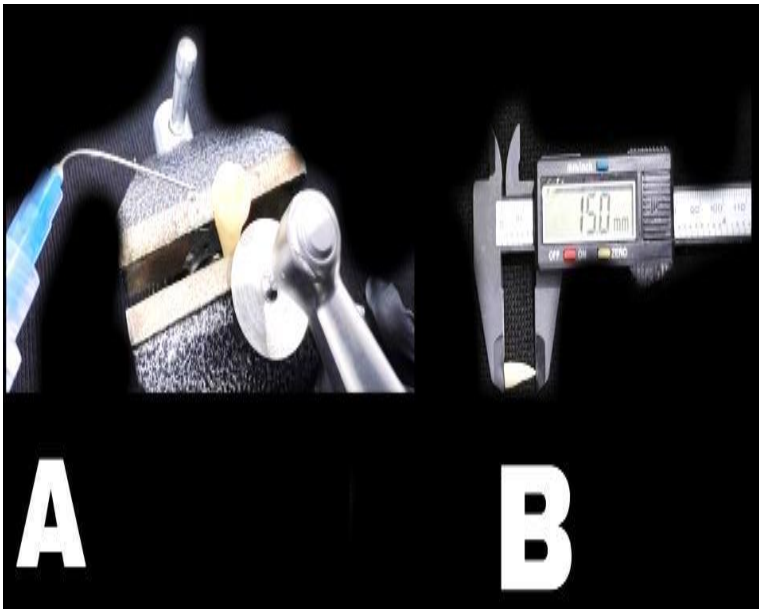

Fig. (1): (A) Decoronating the tooth by diamond saw bur. (B)Calibrating the root length by Vernia.

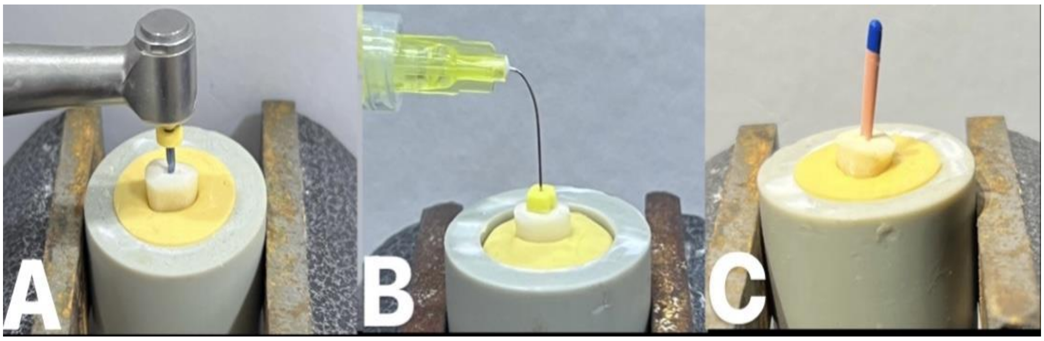

Fig. (2): mounting of the mold with fixed samples on bench vice during root canal preparation (A)Instrumentation (B) Irrigation (C) Obturation

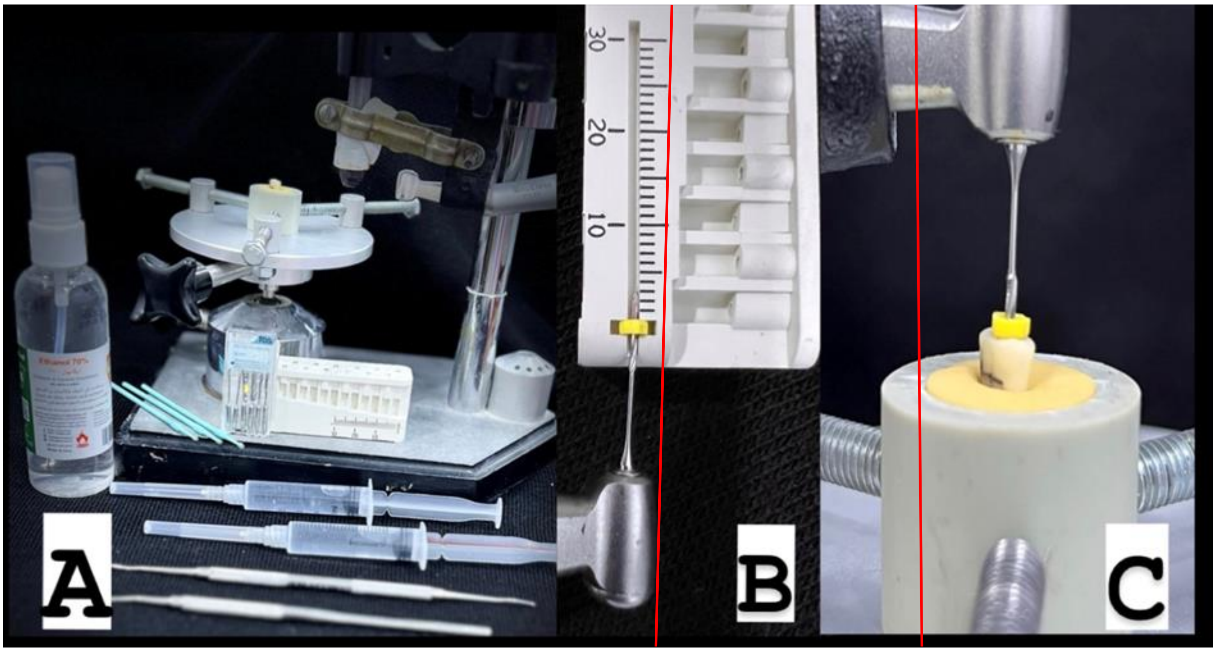

Fig. (3): (A) Instrument used for cavity preparation (B) Determine 3mm of bur (C) cavity preparation

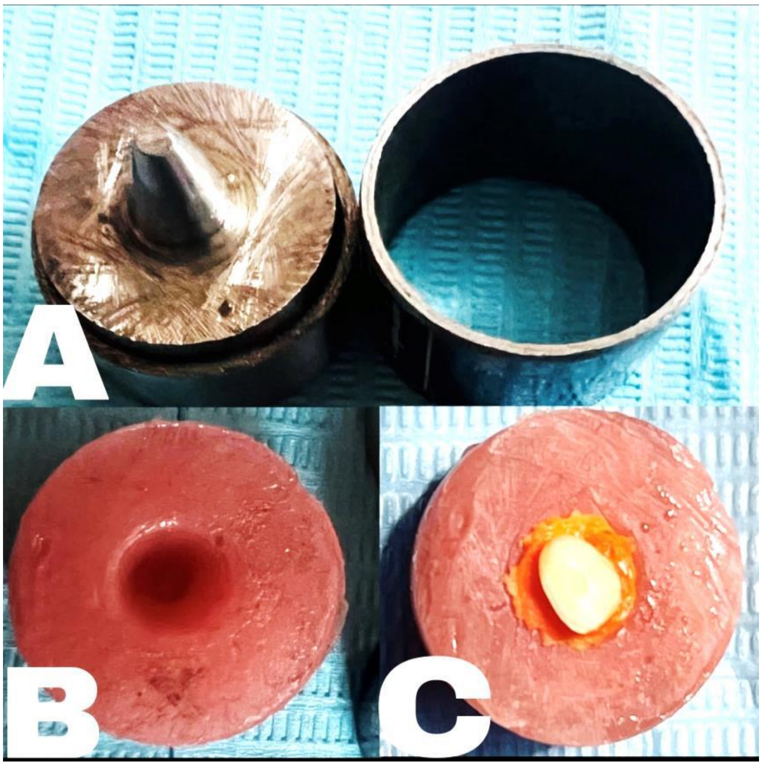

Fig. (4): Mounting of specimens for fracture resistance test (a) special metal mold (b) resin block (c) resin block with the specimen.

Fig. (5): A universal testing machine using a steel spherical tip with a diameter of 2 mm was aligned at the center of the canal opening of each specimen.

Fig. (6): The stereoscopic microscopy system.

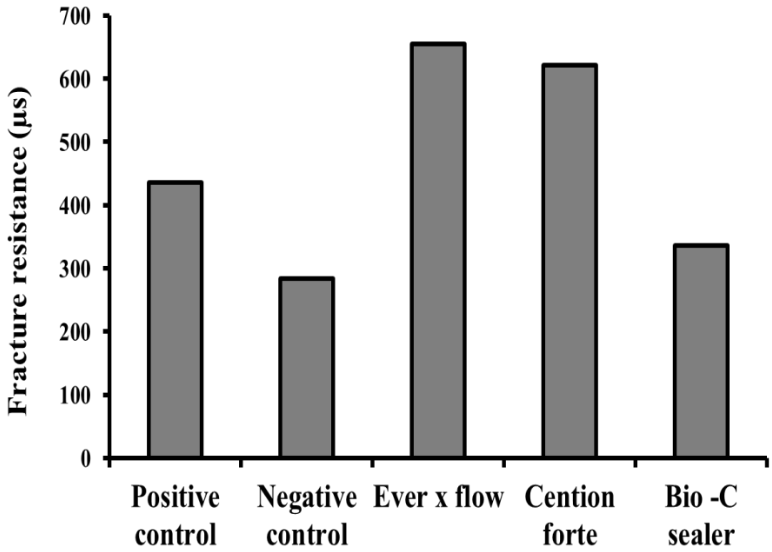

Fig. (7): Bar graph depicting a comparison of fracture resistance means (µs) values (Newton) amongst the groups.

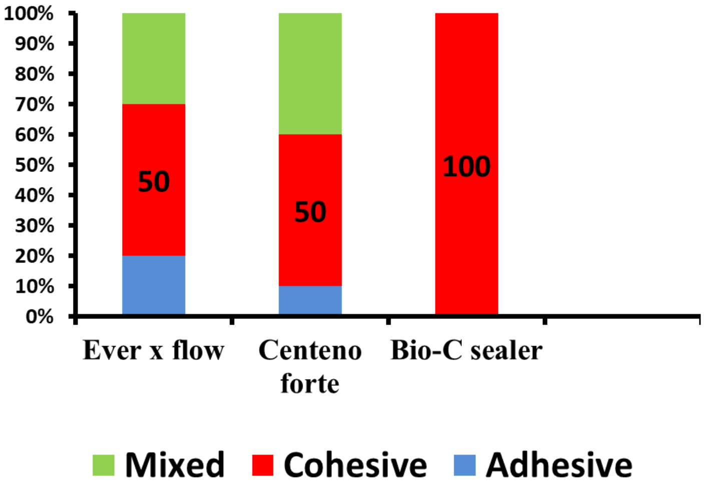

Fig. (8): Modes of failure for intraorifice barrier materials to dentin of endodontic teeth.

Table 1: Characteristics of groups assessed for resistance to fracture with descriptive statistics.

Group	N	Mean ± SD(in Newton, N)	Minimum	Maximum
Positive Control	10	435.4437 ± 33.421 N	391.974	482.733
Negative control	10	283.8305 ± 25.217 N	256.199	325.826
Ever x flow	10	654.6272 ± 66.543 N	570.326	744.571
Cention forte	10	621.0713 ± 111.638 N	447.189	741.194
Bio-C sealer	10	335.8692 ± 91.287 N	319.424	565.601
Total	50	479.229 ± 157.372 N		1.19
N: number of specimens; SD: standard deviation.				

Table 2: Kruskal-Wallis test results for the fracture resistance (Netwon) among groups.

	N	Mean Rank	Kruskal-Wallis H	Asymp. Sig
Positive control	10	24.10	40.760	0.0001 S**
Negative Control	10	5.90		
Ever x flow	10	41.30		
Centionforte	10	38.50		
Bio-C sealer	10	17.70		
Total	50		.	

Table 3: Pairwise comparison of groups by Independent-Samples Kruskal-Wallis Test.

Pairwise comparison	p value/Sig.[a]
Positive control-negative control	0.005
Positive control- Ever x flow	0.008
Positive control - cention forte	0.027
Positive control – Bio C sealer	0.326
Ever x flow – Cention forte	0.667
Ever x flow – Bio C sealer	0.0001
Cention forte– Bio C sealer	0.001
[a] Significance values have been adjusted by the Bonferroni correction for multiple tests.	

Table 4: The Frequency (%) of Failure Modes Among the Experimental Groups (n=10)

Restored Group	Mode I, n (%)	Mode II, n (%)	Mode III, n (%)
Ever x flow	2(200)[a]	5(50.0)[a]	3(30.0)[a]
Cention forte	1(10.0)[ab]	5(50.0)[a]	4(40.0))[a]
Bio c sealer	0(0.0)[b]	10(100)[b]	0(0.0)[b]
Total	3(10.0)	20(66.6)	7(23.3)
Different letters (a,b) denote significant differences in mode of failure between study groups (p<0.05).			

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