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Abstract.

Background: Endodontic failure can result from insufficient coronal seal, which induces post-endodontic infections. Therefore, the intra-orifice barrier is a reliable substitute technique to reduce coronal leakage in teeth where endodontic therapy has been performed.

Aim: To evaluate the effect of three different restorative materials (Ever X Flow, Centeno forte, and Bio-C sealer ION) as intraorifice barriers (IB) of endodontic ally-treated teeth on Coronal microleakage represented by Internal adaptation of barrier materials to radicular dentin and Porosity of materials.

Materials and Method: Forty-four removed human mandibular premolars were chosen, and decorated to a standardized root length (15 ± 0.5mm), a digital caliper was used to measure the mesiodistal and buccolingual diameters of the coronal plane of root to roughly similar buccolingual (BL) and mesiodistal (MD) dimensions (7.5 ± 0.5mm and 4.5 ± 0.5 mm respectively) and the coronal plane of the root canal be approximately similar in buccolingual (BL) and mesiodistal (MD) dimension (3.2 ± 0.2 and 1.8 ± 0.2 mm respectively). The roots were prepared and obturated with gutta-percha and AH Plus sealer, then divided into one control group to three equal groups according to the type of intraorifice materials (n=10). Except for the control group, the coronal 3-mm of gutta-percha was removed and filled with Ever X Flow, Cention forte, and Bio-C sealer ION. After this, all groups underwent thermostatic cycling ageing (1000 cycles, water temperature (5–55°C), dwell time 30s, and transfer (draining) time 10s between cycles). With cycling ageing (1000 cycles, water temperature (5–55°C), dwell time 30s, and transfer (draining) time 10s between cycles). With micro-computed tomography (µCT), three-dimensional gap volumes in the barrier-dentin contact and the porosity of the barrier materials were investigated.

Results: The results showed a significant difference between the control and three types of barrier materials at (P 0.05); Ever X Flow demonstrated lower values of the internal gap of barrier materials to radicular dentin and porosity while the control demonstrated higher values of the internal gap to radicular dentin; however, there was no significant difference between the control and Bio-C sealer ION.

Conclusion: When compared to teeth treated with endodontics but without intraorifice barriers (IOB), those with IOB have less coronal microleakage.

Key words. Intraorifice barrier, barrier materials, endodontic treatment.

Introduction.

The success of endodontic treatment depends on several factors such as the preoperative status of the root canal, the presence of a periapical lesion, the quality of root canal treatment, and the apical and coronal seal [1]. One of the most common problems is the phenomenon of microleakage, which seems to affect most, if not all, restorative materials. Microleakage is defined as the “diffusion of the bacteria, oral fluids, ions, and molecules into the tooth and the filling material interface”. Clinical investigations, both in vitro and in vivo, have shown that a post-endodontic coronal seal is equally important as an apical seal to prevent bacterial penetration in the filled root canal system, causing recontamination and failure of the root canal treatment [2].

The important objectives of post-endodontic restoration are providing an impermeable hermetic seal and increasing root fracture resistance [3]. Therefore, the use of intraorifice barrier (IB) restorative materials for endodontic ally-treated teeth was primarily suggested to prevent bacterial contamination. It would be advantageous to place material over the coronal gutta percha to act as a barrier to coronal microleakage in order to decrease leakage and improve treatment outcomes [1].

The process entails removing a portion of the coronal gutta-percha and then replacing the empty space with a restorative substance (IB). Since some studies tested various intraorifice barrier depths, ranging from 1 mm to 4 mm, and found that it typically had a better performance when it was placed at (3 mm) depth, it appears that the depth of the barrier is a key element in reducing microleakage [4].

The ideal characteristics of intraorifice barrier materials include the ability to bond to the tooth structure, prevent microleakage, be easily manipulated, and be distinguished from natural tooth structure, and they should also not interfere with the final restoration [5]. The effectiveness of barrier materials as sealants has been assessed using a variety of methods, including the fluid filtration method, bacterial and dye leakage. During leakage analysis, sample degradation is caused by bacterial and dye leaking procedures. The advantages of the computerized fluid filtering method far outweigh the drawbacks of other approaches, and this approach is computerized, very sensitive, totally electronic, safe, and equipped with a digital air pressure checking system [5].

As an alternative, micro-computed tomography (-CT) is a nondestructive technique for assessing the three-dimensional integrity of intraorifice materials to replace or support conventional leakage investigations, in which technical errors and a lack of uniformity may compromise the validity of the findings. Significant advancements in hardware and software have recently brought traditional CT’s isotropic resolution (0.5–1 mm) down to that of modern µ–CT systems (10 µm) and lower [6]. The three-dimensional gap volumes in the barrier-dentin interface and the porosity of the barrier materials, which indicate coronal microleakage of intraorifice barrier materials, can be evaluated using the µ-CT data [7]. Numerous intraorifice materials have been employed, including glass-ionomer cement (GIC), resin-based composite (RBC), bio-ceramic cement, zinc phosphate cement, and others [4].
To replicate the stress-absorbing qualities of dentin, short fibre-reinforced composite (SFRC) was released onto the market in 2013. The SFRC material is designed to be utilized as a bulk basis in high-stress locations for rebuilding both vital and non-vital teeth. It can theoretically match the dentin's fracture resistance and is simple to utilize in increments of 4 mm deep. The SFRC is made up of the resin matrix containing Bis-MEPP 15-25%, TEGDMA 1-10%, and UDMA 1-10% and the fillers are a mix of short E-glass fibres and particle fillers, mostly barium glass. Average length of fibres 140μm diameter 6 μm. The total filler rate is 70% in weight. fibres (w/w) 25% according to the manufacturer (GC Corporation Tokyo, Japan) [8].

Alkaside materials are a newly developed family of resin-based ion-releasing compounds. The name is derived from their alkalinizing qualities brought on by the discharge of hydroxide (OH) ions made by Ivoclar Vivadent (Schaan, Liechtenstein). Cention is a bulk-fill restorative material with photoinitiators and chemical catalysts that enable a dual cure polymerization mechanism. The material releases Ca²⁺, F, and PO₄ ions in neutral and acidic conditions, causing apatite to form on its surface. It also has an acid-neutralizing capability and prevented the demineralization of enamel and dentine when exposed to lactic acid for an extended period. The initial hand-mixed material was Cention N (Ivoclar Vivadent), whereas Cention forte (Ivoclar Vivadent) is a capsulated variant. The components of Cention forte are liquids of UDMA, aromatic aliphatic UDMA, DCP, and PEG-400- DMA and powders of inert barium alumino-boro-silicate glass, ytterbium fluoride, calcium fluoro-alumino-silicate glass, and a reactive SiO₂-CaO-CaF₂-Na₂O glass. Hydroxypoxide, Ivocerin, and acyl phosphate oxide make up the initiator system. 58-59 vol%, or filler, depending to the manufacturer(Ivoclar viva-dent AG9494/ Liechtenstein) [9].

Bioceramics are non-metallic, inorganic ceramic materials created especially for use in the medical and dentistry fields. Bioactive or bio-inert materials are used to categorize bioceramic materials [10]. Endodontics utilizes bioceramics extensively because of their excellent qualities in terms of biocompatibility, osteoinductive capacity, ability to achieve an excellent hermetic seal due to hygroscopic expansion capacity, chemical bonding with the tooth structure, antibacterial proprieties, and good radiopacity [4].

However, With recent advancements in bioceramics, the handling qualities were enhanced with the advent of premixed bioceramics. These pre-mixed bioceramics are all hydrophilic, which results in a more homogeneous mixture and a consistency similar to putty that only sets in the right environment, giving sealers the advantage of uniform consistency and lack of waste. In this investigation, pre-mixed bioceramics with a bio-C sealant are used. Depending on the producer (Angelus, Londrina, PR, Brazil), the ingredients in bio-C sealer include calcium silicates, calcium aluminate, calcium oxide, zirconium oxide, iron oxide, silicon dioxide, and dispersion agents [11].

Therefore, the purpose of this study is to assess the impact of (Ever X Flow, Cention forte, and Bio-C sealer ION) as intraorifice barriers (IB) for endodontic ally-treated teeth on coronal microleakage, which is represented by internal adaptation of barrier materials to radicular dentin and material porosity. These were the null hypotheses [1]. In endodontic ally-tREATED roots, there was no discernible difference in the internal adaption of the three intraorifice barrier materials.

**Materials and Methods.**

Sample preparation: Forty single-rooted non-curious human mandibular premolar teeth with nearly similar dimensions, extracted for orthodontic treatment, were used for this study. Soft tissue and calculus were mechanically removed from the root surfaces using a periodontal scaler, then The teeth were stored in 0.1% thymol solution at room temperature until use.

The teeth are decorated with a diamond saw while being cooled by water, and digital Vernia is used to ensure a root length of 15 0.5mm to the standardization sample length shown in (Figure 1). The root canals were accessed, using a barbed broach to remove pulp tissues. A #10 K-file (Rogen Dental, China) was inserted into the root canal, with the working length being established via a stereomicroscope and being 1 mm shorter than the length when the file was observed at the apical foramen [12].

Using a digital calliper (SPAC Systems, Pune, Maharashtra, India), standardize the buccolingual and mesiodistal diameters of the coronal plane of the root and root canal. The coronal plane of the root canal was chosen to be roughly similar in buccolingual (BL) and mesiodistal (MD) dimensions (7.5 0.5mm and 4.5 0.5mm, respectively), and the roots were chosen to be roughly similar in both dimensions (3.2 0.2 and 1.6 0.2 mm, respectively). Roots that were presented with deviations of greater than 10% from the mean mesiodistal and buccolingual diameters of the coronal plane were disregarded [1,12,13].

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 centimetres and height of two centimetres. Every tube was filled with polyvinyl siloxane impression material that had been mixed in accordance with the manufacturer's instructions. Each root had been placed in the centre of the PVC tube, with its long axis running parallel to the sides of the PVC tube. The impression material-filled PVC tube extended 3 mm below the root's coronal end. To allow the impression material to be fully set and allow the surveyor arm to be detached from the tooth without positional deformation, the root sample was kept in place for 10 minutes [14].

The root canal instrumentation procedure was carried out using the crown-down technique and a ProTaper Universal rotary file system (Rogin Dental, China) mounted on an E-Connect S end motor (Eighteenth, Medical) at speed and torque of 250 rpm and 300 Ncm, respectively, using sequentially SX, S1, S2, F1, F2, and F3 files, per the manufacturer's recommendations [15].

The irrigation operation was carried out using 2 ml of 5.25% sodium hypochlorite (NaOCl) solution from (AQUA Medical in Istanbul, Turkey) in each file change, The root canals were then rinsed with 5mL of 17% EDTA (Prime Dental Products, Mumbai, India) for 1 minute to remove the smear layer, and 5mL of normal saline for the final rinse. A disposable irrigation needle gauge 27 with a side vent was used for the irrigation procedure [12,16].

After the root canals were dried using F3 paper points, the obturation technique was carried out using a single cone
matching gutta-percha (Rogin dentistry, China) and AH Plus Sealer (De Trey-Dentsply, Konstanz, Germany) mixed in accordance with product instructions. Glass ionomer cement (White Cimpat; Septodont, So Paulo, SP, Brazil) was used to seal the root canal openings. The samples were kept in storage for 24 hours at 37°C and 100% humidity [12,17].

**Intra-orifice barrier (IB) Cavity Preparation:** The cement material was removed, and the coronal 3 mm of the root canal filling material was removed in experimental groups except for the control group. To the standardized depth of 3 mm of the intra-orifice barrier, the cavity was prepared using Post space preparation drills (peso reamer, size #4, width1.3 mm). The drill was used in a low-speed handpiece (Kavo Ind. Com. Ltda., Joinville, SC, Brazil) at 15,000 to 20,000 rpm and a stopper placed at 3mm from the tips and depth of 3 mm of the intra-orifice barrier cavity verified with the help of William's periodontal probe [13,17].

A cotton pellet soaked in 70% ethanol was then used to scrape and remove any remaining sealant or gutta-percha from this area. After rinsing with 1 ml of 17% EDTA solution and 1 ml of saline, the prepared orifice cavities were gently air-dried [18].

**Grouping of the specimens:**

Forty prepared roots were selected randomly for μ-CT evaluation and distributed randomly into one control and three equal experimental groups (n = 10).

**Group I:** control (fully obdurate root canal without intraorifice barrier cavity preparation).

**Group II:** Intraorifice barrier cavity filled with short fibre-reinforced flowable composite (Ever X FLOW, GC Corp).

**Group III:** Intraorifice barrier cavity filled with Cention forte (Ivoclar Vivadent).

**Group IV:** 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 manufacturer as follows:

- Sort fibre-reinforced flowable composite (EverX FLOW, GC Corp).

A one-step self-etch adhesive, G-Premio Bond (GC Corp, Tokyo, Japan), was applied, and cavities were then dried for 5 seconds under maximum air pressure and light-cured for 10 seconds. Fibre-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/cm²2 light intensity.

- Cention forte (Ivoclar Vivadent).

Simply, apply Cention Primer and scrub it into the prepared cavity. Activate the Cention Forte capsule, mix the contents for the 15s band fill the material in the cavity. Once the material has been set, it can be finished with suitable tungsten carbide burs.

- Bio-c sealer ion (Angelus).

This material is a ready-to-use formula in injectable syringes, NO MIXING.

After the placement of intraorifice barrier materials, all specimens were stored at 37°C and 100% humidity for 1 week in an incubator [3].

**Artificial ageing (Thermo-cycling):**

Thermo-cycling ageing was carried out at Ankara University/Faculty of Dentistry. all specimens were cleaned of mould, and the root of each specimen was given two coats of nail polish, leaving only the canal opening exposed to offer consistent control of any lateral or accessory canal. After the specimens had been gauze-wrapped, they had been put in a small, porous packaging that had the number of the 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. For 1000 cycles (5-55°C), all specimens were thermocycler in distilled water with a dwell time of 30 s and draining times of 10s [19,20].

**Computerized Micro-tomography (μ-CT):**

a. **Micro-CT image analysis:** Micro-Computer Tomography was used to inspect each root (Bruker Sky scan 1275). The root was secured using foam inside a cylindrical container, as seen in (Figure 2) which was specifically designed for that specimen, scanning was restricted to a root section that included the barrier (IB) and the highest portion of the root canal filling [7,21].

The Skyscan, 1275 scanning parameters were set to an acceleration voltage of 80 (kvp), a beam current of 125 (μA), a 1 mm Al/Cu filter with an isotropic resolution of 15 m (3.375 m voxel size), rotation of each sample by 360° in 0.2° steps throughout a 5 min integration time, and air calibration of the detector before each scanning [7,22].

The samples were visualized and quantitatively measured using the NRecon program (version 1.7.4.6, SkyScan, Kontich, Belgium) and CtAn (version 1.20.3.0, SkyScan), which employed a modified version of the technique to produce two-dimensional (2D) axial pictures. beginning at the root's most apical point and every 0.5 mm thereafter. The final micro-CT

![Figure 1](image1.png)  
**Figure 1.** (A) Decorating the tooth with diamond saw bur. (B) Calibrating the root length by Vernia.

![Figure 2](image2.png)  
**Figure 2.** (A) Tooth specimen with a special template mounted on the μ-CT stage. (B) Tooth specimen mounted in a special template made from a small round foam fitted with a small cavity.
images were then coded and converted to TIFF files. With the help of the NRecon program (SkyScan, Kontich, Belgium), the scans were reconfigured to display 2D slices of the roots. From the entire volume of the micro-ct scanning, which was rebuilt by CTAn software, several cross-sectional pictures perpendicular to the long axis of the root were created. To see the samples in three dimensions, CTvox (version 3.3.1, SkyScan, Kontich, Belgium) was utilized. The samples were shown in a 2D data viewer (version 1.6.0.0, SkyScan, Kontich, Belgium) [22].

b. Evaluation of Internal adaptation with μ-CT: To evaluate internal adaptation (gap or interface voids) that are present between the root dentin and IB which was measured on μ-CT images. A set volume of interest (VOI) was defined as a full cross-sectional area of 1.09 mm along the long axis of the barrier. Then a 3 *3 *3 Gaussian filter was used to remove high-frequency noise near the barrier-dentin interface. Semi-automatically drawn contours were generated to define a mask for the barrier VOI. This mask was then smoothed with a 3-pixel morphologic dilation-erosion step. A 7-pixel (42 µm) space centred on the barrier-dentin border defined by the mask was then used to identify gap space via a global grayscale threshold. The gap volume was determined by simple voxel counting in the resulting binary gap image [7].

For the picture analysis, a finishing technique was used to produce a repeatable and operator-independent approach for determining the structural parameters and differentiating the proportion of voids. A total of 40 teeth were scanned to produce the diagrams. Dentin, materials, and voids were the examined components; the threshold level was determined by the peak separation points of the diagrams. With the aid of the program Catalyzer (version 1.10.1.0, Sky Scan), the 3D distribution of interface voids inside a predetermined VOI was estimated. Void volumes wider than 10.21 µm³ with 1.35 µm diameter were detected. Through-and-through voids (continuous pores) and cul-de-sac-type voids (blind pores) were distinguished. Each 3D VOI had a 42-micron-thick interface volume that included the initial 21 microns of the IB and the superficial 21 microns of the canal wall dentine, as seen in (Figure 3) [21].

Based on the known voxel volume of 216 m³, the VOI and any detectable mean gap size were calculated directly. Any detectable gap volume between the barrier and dentin walls was calculated and analyzed by dividing the body volume excluding the pores (BV) on the total gap volume (TV) [7].

b. Evaluation of void with μ-CT:

Based on the CT values contrast between the structure of the IB materials and the air trapped in each void, 3D imaging software (TRI/3D-BON; Ratoc, Tokyo, Japan) is used to extract the IB materials and maintain the void. The software's volume calculation tool was then used to calculate the volume of each void (Vv) and the void frequency (Vf) parameter [23].

\[ \text{Gap volume} = \frac{BV}{TV} \]

\[ \text{Void Volume (Vv)}: \]

The dimensions of each void calculate by measuring the distance between the peaks at the top and bottom and void volume percentages (VP) for each IB material were obtained as the following equation [24]:

\[ \text{VP}\% = \frac{\text{Sum of voids volume within IB}}{\text{Volume of IB}} \times 100\% \]

Void Frequency (Vf):

The total number of independent voids within each IOB conducts in μ-CT obtained from each specimen [24].

Statistical analysis: The data for this study were gathered, tabulated, and statistically analyzed using a suitable personal computer and IBM SPSS (SPSS for Windows, IBM Corp., Version 26) social science software. At the significance level of (P≤ 0.05), Kolmogorov-Smirnov and Shapiro-Wilk tests were used to evaluate the normality of data distributions and homogeneity of variance.

The Kruskal-Wallis test was used for variance analysis with a K-independent sample because the data obtained were not normally distributed, and the Independent-Samples Kruskal-Wallis Test was used to compare significant results.

Results.

a. Internal adaptation of barrier materials to radicular dentin:

A descriptive investigation of the internal adaptation of barrier materials and control groups to radicular dentin (Table 1).

Using the Kruskal-Wallis test, a statistical analysis of the mean of internal adaptation of control and barrier materials to radicular dentin of each group is shown in (Table 2). The results showed a
highly significant difference between the control group and the three different kinds of barrier materials (Ever x flow, Cention forte and Bio-C sealer) at (P≤ 0.05).

Ever x flow exhibited the least amount of internal gap to radicular dentin while the control group showed the highest amount of internal gap to radicular dentin which is represented in (Figure 4 and Figures 5).

Additionally, Independent-Samples Kruskal-Wallis Test was used to statistically assess comparisons between the groups as shown in (Table 3). The results showed that there was no significant difference between the Ever x flow and Cention forte (p=0.333), a highly significant difference between the Ever x flow and Bio-C sealer and control group at (P =0.000), a significant difference between the Cention forte and Bio-C sealer at (p=0.033), and No significant difference between the Bio-C sealer and control group at (p=0.333).

b. Porosity of barrier materials:

The porosity of intra-orifice barrier materials mentioned in Table 4.

The Kruskal-Wallis test was used to statistically assess the mean internal porosity volume and percentage (%) of barrier materials for each group, as shown in (Table 5). The results showed a highly significant difference (P 0.05) between the three types of barrier materials (Ever x flow, Cention forte, and Bio-C sealer) at (P≤ 0.05).

Ever x flow exhibited the least mean of internal porosity volume and % while Bio-C sealer showed the highest mean of internal porosity volume and % which is represented in (Figure 6 and Figure 7).

In addition, comparisons between the groups were statistically analyzed using Independent-Samples Kruskal-Wallis Test as represented in (Table 6). The results showed a significant difference between Ever x flow and Cention forte (p=0.033), a highly significant difference between Ever x flow and Bio-C

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**Table 1.** Mean values of internal adaptation of barrier material and control group.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>10</td>
<td>1.4</td>
<td>0.12</td>
<td>1.22</td>
<td>1.54</td>
</tr>
<tr>
<td>Ever x flow</td>
<td>10</td>
<td>0.56</td>
<td>0.07</td>
<td>0.48</td>
<td>0.64</td>
</tr>
<tr>
<td>Cention forte</td>
<td>10</td>
<td>0.75</td>
<td>0.12</td>
<td>0.66</td>
<td>0.96</td>
</tr>
<tr>
<td>Bio-C sealer</td>
<td>10</td>
<td>1.11</td>
<td>0.07</td>
<td>1.03</td>
<td>1.19</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>0.81</td>
<td>0.25</td>
<td>0.48</td>
<td>1.19</td>
</tr>
</tbody>
</table>

N: number of specimens; SD: standard deviation.

**Table 2.** Kruskal-Wallis test results for Internal adaptation of the control group and three types of barrier materials to radicular dentin.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean Rank</th>
<th>Kruskal- Wallis H</th>
<th>Asymp. Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>10</td>
<td>35.5</td>
<td>36.7</td>
<td>0.00 S**</td>
</tr>
<tr>
<td>Ever x flow</td>
<td>10</td>
<td>5.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cention forte</td>
<td>10</td>
<td>15.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bio-C sealer</td>
<td>10</td>
<td>25.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Means with letter S** have highly significant at (P ≤ 0.05)

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

<table>
<thead>
<tr>
<th>Sample 1-Sample 2</th>
<th>P value/Sig.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ever x flow- cention forte</td>
<td>0.333</td>
</tr>
<tr>
<td>Ever x flow – Bio c sealer</td>
<td>0.001</td>
</tr>
<tr>
<td>Ever x Flow – Control</td>
<td>0.000</td>
</tr>
<tr>
<td>Cention forte- Bio c sealer</td>
<td>0.033</td>
</tr>
<tr>
<td>Cention forte– Control</td>
<td>0.001</td>
</tr>
<tr>
<td>Bio c sealer– Control</td>
<td>0.333</td>
</tr>
</tbody>
</table>

a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

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**Figure 5.** Exhibited a 3D image that indicated how the amount of internal gap at the tooth-restoration interface changed in response to the application of barrier materials (blue arrows)(A) Control (B) Ever x flow (C) Cention forte (D) Bio-C sealer.

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Figure 6. Column graph depicting a comparison of Porosity volume and percentage (%) mean (µs) values amongst the groups.

---

Figure 7. 3-D-CT images showing porosity within barrier materials(green arrows) (A) Ever x flow (B) Cention forte (C) Bio-C sealer.
One of the modern techniques for reducing contamination is the use of intra-orifice barriers (IB) made of different materials [25]. These IB prevent the re-contamination of the canals and reactivate the endodontic illness. The majority of scientific research has concentrated on developing tools and methods to strengthen the apical seal. Recent investigations have shown that an insufficient coronal seal increases the likelihood of re-infection because bacteria from the oral environment can enter. It has been demonstrated that the present methods for post-endodontic restorations and root canal obturation are insufficient to achieve a complete coronal seal [25].

Microleakage is a significant criterion for assessing the effectiveness of restorative materials. Both shrinkage and a poor fit between the cavity walls and the restorative material might result in minor leaks. Recurrent caries and pulp disease are brought on by this microleakage [26]. One of the modern techniques for reducing contamination in endodontically treated root canals involves creating an impermeable barrier between the oral environment and the root canal system. The intra-orifice barrier is an effective stand-in method for lowering coronal leakage in teeth that have undergone endodontic therapy. This method involves removing the gutta-percha cones and sealer before injecting additional material with different restorative ingredients into the canal orifices before the ultimate restoration is completed [1].

This study assessed the potential of 3 materials for use as IB for endodontic teeth in order to decrease coronal microleakage by using micro-CT analysis to assess the presence of marginal gaps and internal voids (measuring the volume and percentages) formed after placement of intraorifice barrier (IB) in extracted human teeth. Data from this study indicated that endodontic teeth with (IB) had less coronal microleakage than endodontic teeth without (IB) based on radiography and CT findings. The coronal microleakage of the intraorifice barrier (IB) made of the ever-x flow (short fibre-reinforced composite) (SFRC) was significantly lower than that of the control and other groups of IB made of different materials (P ≤ 0.05). These differences may be attributed to differences in the type of restorative material used and the properties of the material's constituent parts.

The findings of this investigation Dental SFRCs typically contain inorganic filler particles and short or nanofibers as reinforcing components in a resin matrix. For every x flow (short fibre-reinforced composite)(SFRC) that may be explained as connected to their composition and physical qualities, The effectiveness of fibre reinforcement is significantly influenced by the type of crosslinking at the fibre and resin matrix interface, as well as the fibres' orientation, distribution, aspect ratio, and volume percentage [27].

When used as intracanal anchorage in the post-endodontic reconstruction, Ever X Flow, a discontinuous glass fibre-reinforced resin composite resin, produced push-out retentive strengths comparable to those of conventional fibre posts because of the composition of Ever X Flow, which is made up of a resin matrix, broken E glass fibres, and inorganic particle fillers. Semi-interpenetrating Polymer Network (semi-IPN), a polymer matrix formed by cross-linked monomers such as bisphenol-A-glycidyl dimethacrylate (bis-GMA), triethylene glycol dimethacrylate (TEGDMA), and linear polymethyl methacrylate (PMMA) in resin matrix, increases the toughness of composite materials and provides good bonding properties [28,29].

Another explanation for the observed ever-x flow is that it exhibits less polymerization shrinkage than conventional particulate filler composite (PFC) resin, which results in contraction stress at the interface between the resin and cavity walls, causing gap formation and secondary caries, attributed this to the possibility that short fibre fillers with random orientations could absorb some of the stresses brought on by polymerization shrinkage and improve the matrix's resistance to stress, which could decrease marginal microleaks and improve the material's flexibility [30].

The SFRC's polymerization shrinkage stress relaxation behaviour According to the fibre's aspect ratio, which is the ratio

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### Table 4. Descriptive statistics of porosity volume (mm) and percentage (%) of intra-orifice barrier materials.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ever x flow</td>
<td>10</td>
<td>0.88</td>
<td>2.2</td>
<td>0.05</td>
<td>2.14</td>
</tr>
<tr>
<td>Cention-forte</td>
<td>10</td>
<td>1.4</td>
<td>2.8</td>
<td>0.1</td>
<td>2.56</td>
</tr>
<tr>
<td>Bio-C sealer</td>
<td>10</td>
<td>1.7</td>
<td>4.4</td>
<td>0.06</td>
<td>3.98</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>1.33</td>
<td>3.1</td>
<td>0.37</td>
<td>2.14</td>
</tr>
</tbody>
</table>

**N:** number of specimens; **SD:** standard deviation.

---

### Table 5. Results from the Kruskal-Wallis test for the internal porosity volume and percentage (%) of three different kinds of barrier materials.

<table>
<thead>
<tr>
<th></th>
<th>No</th>
<th>Mean</th>
<th>Kruskal-Wallis H</th>
<th>Asymp. Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ever x flow</td>
<td>10</td>
<td>5.50</td>
<td>25.8</td>
<td>0.0 S**</td>
</tr>
<tr>
<td>Cention-forte</td>
<td>10</td>
<td>15.50</td>
<td>25.8</td>
<td>0.0 S**</td>
</tr>
<tr>
<td>Bio-C sealer</td>
<td>10</td>
<td>25.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Means with letter S** have highly significant at (P ≤ 0.05).

---

### Table 6. Pairwise comparison of groups by Independent-Samples Kruskal-Wallis Test.

<table>
<thead>
<tr>
<th></th>
<th>Sample 1-Sample 2</th>
<th>Sig.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ever x flow-cention forte</td>
<td>0.033</td>
<td></td>
</tr>
<tr>
<td>Ever x flow–Bio c sealer</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Cention forte–Bio c sealer</td>
<td>0.033</td>
<td></td>
</tr>
</tbody>
</table>

*Significance values have been adjusted by the Bonferroni correction for multiple tests.
of the fibre's length to diameter (l/d) and the amount of fibre as a filler used. Fiber of Ever X Posterior has had a bigger aspect ratio (17 µm × diameter 800 µm in length) than that fibre of Ever X flow (6 µm diameter ×140 µm in length). The fibre orientation will therefore remain parallel in the centre of the resin when filled into the glass tube, but the fibres will entwine in the inner wall of the glass tube and the filled area. It's also believed that the polymerization shrinkage along the glass fibre fibres is not very significant. This indicates that, despite the matrix resin between the fibres polymerizing and contracting, the interwoven fibre absorbed the stress at the inner wall of the glass tube, where the greatest polymerization shrinkage stress was applied. Large aspect ratio fibres intertwine with one another in the cavity and help decrease the considerable polymerization shrinkage stress during light irradiation, in contrast to fibres with a small aspect ratio, but fibres with a small aspect ratio are able to carry and scatter the irradiation light to every part of the cavity. As a result, the stress brought on by polymerization shrinkage after light irradiation was successfully reduced. This phenomenon is thought to be important in deep cavities where irradiation is difficult [27,31].

An isotropic or semi-anisotropic reinforcing effect is provided by the discontinuous, randomly oriented, and longer than the critical fibre length fibres used in the Ever X flow. This effect is related to the fibre adhesion to the polymer matrix, which is based on stress transfer from the polymer matrix to fibres, and individual fibres act as a crack stopper to prevent crack growth. It is also possible that the discontinuous glass fibres, which have a diameter of 5–6 micrometres, could micromechanically interlock the imperfections on the dentine surface, increasing the adhesive capabilities under shear stress [27,29].

The polymerization reaction of resin material is related positively to a depth of cure, The transfer of light energy may be significantly impeded by SFRC fibres. This effect further stresses the importance of the depth of cure and the necessity of suitable clinical curing settings, particularly when using anisotropic fibre systems. The deepest cure (6.7 mm) was likewise seen in the Ever X flow. This may be explained by the influence of relatively well-aligned long fibres through the small mould resulting in a probable "fibre optic-like" boosting light penetration as well as the higher translucency seen in this substance [32].

According to the result of the present study for a new class of resin-based ion-releasing alkasite materials (Cention forte) have marginal gaps and internal voids higher than short fibre-reinforced composite (SFRC) and lower than new calcium silicate–based root canal sealer (Bio-C Sealer) that could be explained as related to Cention forte have ion-releasing property included the release of ions or any other substances from a restorative material always raises questions regarding the possibility of useful filler particles dissolving. This could lead to voids in the set material when it is placed in an aqueous environment, which would promote water sorption and further dissolution. Internal porosities make restorations more brittle and less resistant to occlusal stresses [9].

Resin-based ion-releasing alkasite materials (Cention forte) show higher solubility than high-viscosity resin-based composites (Bulk Fill material) that is mostly made up of low-viscosity monomers and a dual-cure photoinitiator system is probably going to produce a more porous composite than traditional products that are delivered as a paste in a syringe. Additionally, 24.6 wt% of Cention is made up of alkaline filler particles that are meant to dissolve upon contact with water and release calcium, hydroxide, and fluoride ions as part of the product's claimed remineralizing function. Because fluoride-releasing restorative materials need a certain quantity of water diffusion to work, increased solubility can be anticipated from these materials. Additionally, it has been proposed that the release of fluoride ions from these materials through the dissolution of their fillers could lead to the formation of vacencies on their surface, which could contribute to a decrease in microhardness [33].

Another explanation for the dual-cure bulk-filling and ion-release of alkasite materials (Cention forte) relates to the kinetics of polymerization, either by self-cure mode or light-cure mode. The degree of conversion between self-cured and light-cured is significantly reduced when self-curing is activated by chemical initiators with a slow initiation rate showing the 11-min delay in starting the polymerization reaction, as shown by increases in working time from 2 to 11 min and increases in claimed setting time 6.5 min. Cention self-curing activated by chemical initiators with a slow initiation rate shows the 11-min delay in starting the polymerization reaction as demonstrated by increasing the working time from 2 to 11 min and increasing the claimed setting time to 6.5 min, dramatically lowering the degree of conversion of self-cured versus light-cured. The reactivity for light-cure activated polymerization can be increased due to the better light transmission of these bulk-fill materials and Cention light-curing is activated by additional Germanium-based initiator Ivocerin, which is advantageous for the light-cure mode that exhibits higher light reactivity than camphorquinone that is found in conventional resin composite [34].

A delay in the self-curing Cention polymerization activation caused the mass of the water sorption specimens to rapidly decrease. Leaching of unpolymerized monomers and, to a lesser extent, dissolution of functional fillers, mass loss, and higher solubility (Cention's solubility was associated with the dissolution of functional fillers in an aqueous environment) were also observed. They all arise from incomplete polymerization specimens absorbing water. Therefore, it makes sense why Cention self-cured is more soluble than the Cention light-cure. Cention must always be light cured when being applied to the oral cavity [9].

In addition, researchers evaluated the impact of distinct ion-releasing restorative dental materials' changing polymerization rates on their mechanical characteristics, water sorption, and solubility. The flexural characteristics of CN were discovered to be higher than those of a GIC and lower than those of a traditional resin composite. This substance slowly increased its flexural strength, elastic modulus, solubility, and solubility when allowed to self-cure. On the other hand, when light-cured, CN had significantly lower values in terms of mechanical characteristics and water sorption than other light-cured materials.
materials, at result concluded that Cention should not be used in self-cure polymerization mode due to its inferior chemical and mechanical properties. that can be attributed First, the mixture of UDMA, DCP, an aromatic aliphatic-UDMA, and PEG-400 DMA joins (cross-links) during polymerization. The monomer matrix's key ingredient is UDMA. Having high mechanical qualities, it has a moderate viscosity. High flexural strength is a result of the polymer's strongly cross-linked structure. Which is present within Cention and the missing polymeric structure within Glass Ionomer Cement. Second, nanohybrid composite has a modulus of elasticity ranging from 9 to 15 Gpa, bonds to tooth structure micromechanically, and offers good marginal seal, reinforcement of remaining tooth structure, and conservation of tooth structure, it also has significant flexural strength, while Cention has a modulus of elasticity of 13 Gpa [35-37].

Bio-C Sealer is a new calcium silicate–based root canal sealer, according to the present study result which showed the highest internal gap to radicular dentin and the highest internal porosity, these results related to the physicochemical properties of calcium silicate–based sealers have shown increased solubility following water immersion compared with the usual resin-based sealers, attributed to the hydrophilic nano-sized particles that enhance their surface area and permit more liquid molecules to come into touch with the sealer can be credited for the sealer's high solubility [38].

The use of bioceramic materials as root canal sealers has several significant benefits. The chemical composition and crystalline structure of bioceramic materials are similar to those of bone and tooth apatite materials as a result of the calcium phosphate present in them, which also improves the bonding of the sealer to the root dentin. This finding relates to the fact that Bio C Sealer has the highest solubility when compared to Endo Sequence and Sealer Plus BC. This is due, in part, to the fact that it doesn't include calcium phosphate, which shortens the setting time. Second, Bio C Sealer contains larger particles than Endosequence and Sealer Plus BC, which causes it to disintegrate more quickly [39,40].

Endodontic sealers’ ability to penetrate the dentinal tubules depends on the anatomical root, as do the sealer's physical and chemical properties, the removal of the smear layer, and the irrigation technique employed. Root canal sealtant with a calcium silicate basis, Because the coronal portion of the root contains the majority of the sealant and may experience volumetric changes during setting and dissolution, increasing porosity, as well as the lower density of these materials allowing air bubbles to move from the apical third to the coronal third of the root. Second, the solubility of calcium silicate-based sealers can be explained by the higher solubility of bioactive sealers caused by the release of OH- and Ca+ ions, which may also be the cause of the increase in porosity. As a result, porosity and other defects in the endodontic sealant's microstructure might therefore cause structural weak points, lower the material's tensile strength, and as a result produce microcracks that may cause the endodontic cement to leak in the root canal [38,41]. Therefore, the use of bioceramic materials provides protection of the whole teeth keeping it safe from porosity, enamel loss, and opalescent tooth colour [42].

Conclusion.

Within the confines of this in vitro examination, the μ-CT offers a 3D and non-destructive analytical method for the specimen's interior structures. Conclusions can be drawn from the findings, which demonstrated that placing an intraorifice barrier in teeth that have had endodontic treatment can dramatically reduce microleakage. the control group and bio c sealer demonstrated a higher internal gap to radicular dentin, While Ever X flow demonstrated a reduced internal gap to radicular dentin and material porosity. Ever x flow revealed an internal gap that was less than cention forte but did not differ significantly from it, whereas internal porosity revealed a distinct difference.

REFERENCES

12. Özlek E, Giündüz H. Effectiveness of different rotary file


