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Original Research

Comparative evaluation of voids using calcium silicate-based materials in teeth with simulated internal root resorption defects: An in vitro CBCT study

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ABSTRACT:
Objectives: The obturation quality of MTA, Biodentine, and single cone obturation with Endosequence BC Sealer HiFlow in teeth with simulated internal root resorption (IRR) was evaluated by using cone beam computed tomography. **Materials and Methods:** Standardized IRR cavities were created using 30 extracted mandibular premolar teeth and randomly assigned into 3 groups (n = 10). IRR cavities were filled with MTA, Biodentine, single cone + Endosequence BC Sealer HiFlow. Percentage of voids between resorptive cavity walls and obturation material (external void), and inside the filling materials (internal voids) were measured. **Results:** Single cone + Endosequence BC Sealer HiFlow presented significantly lowest values of external and internal voids ($p < 0.05$),then Biodentine showed a significantly lower external voids ($p < 0.05$),MTA presented the most Voids both internal as Well as external. **Conclusion:** None of the filling materials created void-free obturation in resorption cavities. Single cone + Endosequence BC Sealer HiFlow and Biodentine may favor its application in teeth with IRR over Angelus MTA.

Keywords: Biodentine; Calcium silicate; Internal root resorption; cone beam computed tomography; MTA cement

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INTRODUCTION

Internal root resorption (IRR) is a form of root resorption which breaks down hard tissues of root canal walls as a result of a clastic activity. IRR is commonly caused by trauma or root canal infection [1]. In IRR cases, the pulp tissue apical to the resorptive defect has a viable blood supply, whereas the coronal pulp tissue above the resorptive defect must be infected to provide the stimulation for the clastic activity [1]. If this infected necrotic pulp tissue is not removed by root canal treatment, the pulp tissue apical to resorptive defect also undergoes necrosis, bacteria may infect the whole of the root canal system and consequently apical periodontitis may develop. Therefore, to prevent developing apical periodontitis, endodontic treatment is necessary to remove the infected pulp tissue, disinfect and obturate root canal system and resorptive defect. However, the irregularly concave nature of resorptive defects makes them inaccessible to clean and obturate properly. During the obturation of the resorptive defect, it can be expected from an obturation material to be able to flow and provide an adequate 3-dimensional (3D) obturation.

Endosequence BC Sealer HiFlow is a novel premixed and hydrophilic calcium silicate-based sealer.it forms hydroxyapatite upon setting and chemically bonds to dentine [2]. Calcium silicate-based materials are recommended due to their higher bond strength, which is attributed to their small particle size and excellent level of viscosity [3]. Less than 2 µm of particle size enhances its flow into dentinal tubules, lateral canals, and leading to improved adaptation and gap-free seal [4].

In cases of extensive IRR, the prognosis of endodontic treatment can be compromised due to the weakening of the remaining dental structure. Considering the thin and weakened tooth structure in IRR cases, a calcium silicate-based material might be needed to reinforce the tooth to enhance the prognosis of the tooth. However, to the best of our knowledge, no study exists that compared the obturation quality of these calcium silicate-based materials with gutta-percha/sealer conjunction in teeth with simulated IRR. Therefore, this *in vitro* study was conducted to investigate whether single cone obturation with a calcium silicate-based sealer (Endosequence BC Sealer HiFlow) and calcium silicate-based cements (CSCs; MTA [Angelus, Brazil] and Biodentine [Septodont, Saint-Maur-des-Fossés, France]) may have shown enhanced obturation quality in IRR cases due to their extremely small particle size and level of viscosity. In order to evaluate the obturation quality of these materials, the percentage of voids between dentine walls of resorptive cavity and filling materials (external voids) and inside the filling materials (internal voids) were measured by using cone beam computed tomography (CBCT).

SELECTION OF ROOT CANALS

The teeth were disinfected in 5% sodium hypochlorite solution for 30min.The teeth were then cleaned of calculus,soft tissue tags.debris and attached bone by ultrasonic scalers and washed with distilled water and were kept in normal saline until used.

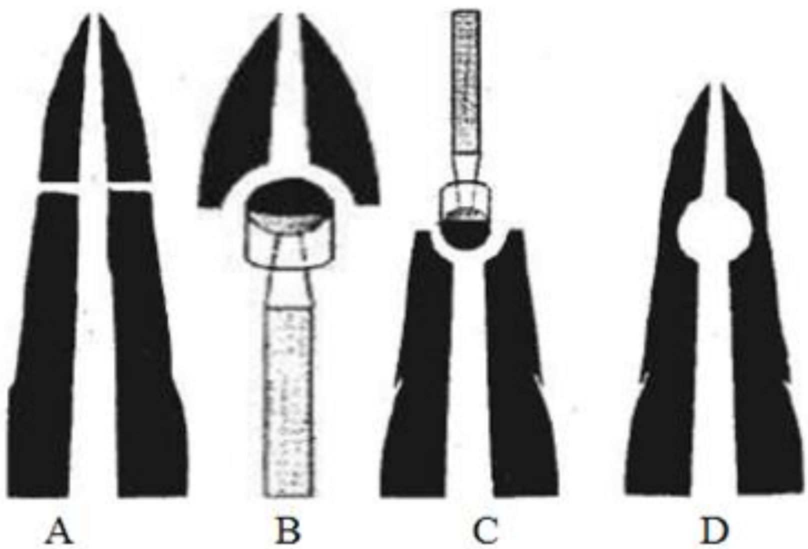
A radiographic platform was used to take standardized radiographs prior to instrumentation with 10k file inserted into the canal in order to determine the degree and radius of the curvature using periapical Kodak Insight Films. The X ray tube was aligned perpendicular to the root canal. The exposure time(0.125;70Kv,7mA) was same for all radiographs. Radiographs were ditizised and the degree and radius of canal curvature were obtained from these preoperative radiographs with a computer program Corel draw X6 software tools using Schneider's technique.

METHODOLOGY

30 single-root teeth premolars (recently extracted for orthodontic reasons) were selected and adjusted to a length of 20 mm through the coronal portion reduction by using a diamond fissure bur. A conventional endodontic access cavity was prepared in each tooth. Then, a size 10 K-file was inserted into the canal until only the tip was visible at the apical foramen. Then length of the file was measured, and 1 mm subtracted from it to determine the working length. After that, ProTaper Universal files (#S1- F3, Dentsply Maillefer, OK, USA) were used. The manufacturer instructions were followed in cleaning and shaping of the root canal system up to F3 file combined with 1 ml of 2.5% sodium hypochlorite irrigation with 30 gauge side-vented needle between each step. Subsequently, all teeth canals were rinsed to remove any remaining smear layer using 1 ml 17% EDTA for 1 min, followed by 5 ml 2.5% sodium hypochlorite irrigation.

A guide mark was placed on the buccal face of each root using permanent marker. Following instrumentation, the simulated internal resorption cavities were created using the following procedure.

Figure: 1



Schematic drawing illustrating the procedure used to make the simulated resorptive cavities.
A. Transverse sectioning of the root 7 mm from the apex;
B. Hemisherical cavity created at the opening of the root canal in the apical half using a round bur with a stopper;
C. Hemispherical cavity created in the coronal half drilled as in B;
D. Both halves glued together showing the simulated internal resorptive cavity (source: Goldberg et al)

All roots were sectioned transversely with a fine diamond disk 7 mm from the apex. At the openings of the root canals of each section, hemi circular cavities were created using a low speed hand piece and a #6 round bur with a stopper, in order to ensure the precise depth of the cavities. A small drop of glue was carried with the tip of a dental explorer and spread carefully on the dentine surface around the prepared cavities and the three groups were obturated as follows:

OBTURATION OF RESORPTIVE CAVITIES

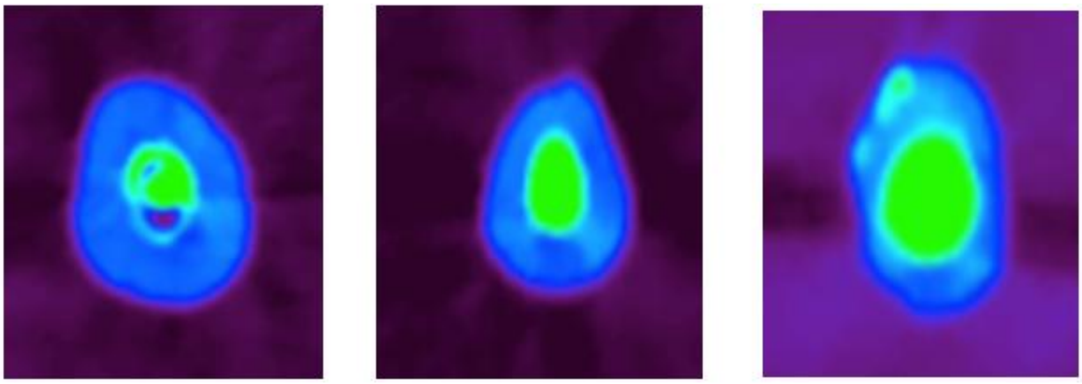
The specimens were randomly divided into 3 groups (*n* = 10) according to filling materials used as follows:

- Group Angelus MTA (White MTA, Angelus, Londrina, PR, Brazil): The powder of MTA was mixed with sterile water in a 3:1 powder/liquid ratio. Then, the cement was incrementally placed into the resorptive cavity and remained root canal (coronal to resorptive cavity) with MTA carrier and was condensed by using a hand plugger.
- Group Biodentine (Septodont,, France): According to the manufacturer's instructions, 5 drops of the liquid were poured into the powder-containing capsule. The capsule was triturated for 30 seconds on an amalgamator. Then, the cement was incrementally placed into the resorptive cavity and condensed.
- Group single cone technique + Endosequence BC sealer HiFlow: A small amount of RCS was injected into the canal and then, GP was injected.

After obturation was completed the samples were wrapped in wet gauze, and allowed to set for 1 week to allow complete setting of filling materials. To evaluate the obturation quality, the volume of voids within the obturation materials (internal) and at their interface with dentin walls (external) were measured for each specimen by using CBCT

CBCT EXAMINATION

Then CBCT scans of samples were taken with FOV size of 8 × 5 cm ; minimum slice thickness of 100 micron having x-ray source of 0.5 mm focal spot, 60-90 kV voltage and 1-10 mA current. Images data was transferred to the computer hard drive and was analysed using NNT software and Horos software.



1 2 3

CBCT IMAGES SHOWING OBTURATION WITH DIFFERENT MATERIALS (1) MTA,(2)BIODENTINE,(3) SC+BCHF

STATISTICAL ANALYSIS

Statistical analysis was performed using SPSS version 20.0. Shapiro Wilk test was used to check the normality of data. Differences among groups were compared using Kruskal-Wallis test. Mann Whitney *U* test was used for intragroup comparison. The threshold for statistical significance was set at $p < 0.05$.

RESULTS

Significant differences were found among groups in terms of external and internal void percentages ($p < 0.05$). Mean values of external and internal voids from highest to lowest were found as follows: MTA > Biodentine> single cone technique + BCHF .The significantly highest value for void percentage was found in MTA ($p < 0.05$), whereas the lowest was found in single cone technique + BCHF ($p < 0.05$).

Table 1. Median and range percentage values of experimental groups (%)

GROUPS	EXTERNAL VOID	INTERNAL VOID
MTA	6.04(3.55-8.62)	0.17(0.06-0.63)
BIODENTINE	3.46 (2.15–4.01)	2.25(0.95-6.53)
SC+BCHF	0.81(0.01-2.38)	0.58(0.01-1.54)

DISCUSSION

Teeth with extensive IRR may become more brittle due to the loss of dental structure. Therefore, materials that were suggested to have reinforcing capacity should be preferred for filling these teeth to prevent fractures.[5] CSCs such as MTA or Biodentine may be considered the material of choice to repair the extensive resorption defects. In addition to that, the selected material can also prevent the spread of a bacterial infection with the lower values of gap size between cement and dentin interface with adequate sealing. However, due to the nature of irregular concave cavity of IRR, the obturation quality of CSCs is unknown. Therefore, this *in vitro* study was conducted to evaluate the obturation quality of MTA, Biodentine, and Single cone + Endosequence BC Sealer HiFlow in teeth with simulated IRR. Voids along the dentin walls of the resorptive cavity and inside the tested materials were evaluated by using CBCT.

In the present study, IRR cavities were simulated on each root halves by using round burs to obtain standardization. This technique may not replicate a real irregular resorptive cavity. However, standardizing the cavity dimensions make it possible to compare. MTA and Biodentine were placed into resorption cavities with hand condensation. In a previous study, El-Ma'aita *et al*.[6] observed fewer voids with hand condensation of MTA root filling than with indirect ultrasonic activation. Sisli and Ozbas [7] and Küçükkaya Eren *et al*.[8] reported that placement techniques did not affect the obturation quality of CSCs. Based on these results of previous report findings, the supplementary placement technique was not used in the present study.

The present study results revealed that there was a statistically significant difference in the quality of the root canal fillings in terms of their ability to fill a resorption cavity. showed significantly lower external and internal voids among experimental groups. Endosequence BC sealer hiflow is a premixed, hydrophilic single syringe that contains calcium silicate with small particle size and excellent level of viscosity, which could minimize the risk of void formation in the RCSs.[9] Endosequence BC sealerHiFlow was preferred due to its flowability and expected to fill the simulated resorptive cavity via direct injection.

According to the results of the present study, Biodentine showed a lower external and internal void percentage than MTA. Biodentine has some features which are superior to MTA; such as its handling characteristics and consistency.[10,11] In a previous study, it was reported that the size of the particle of Angelus MTA was inhomogeneous, and it was surface looks more irregular than Biodentine.[12] In that study, the differences in the chemical composition of calcium silicate cements were reported to affect their clinical performances. Angelus MTA particles vary in size and have low circularity.[13] Therefore, due to these aforementioned reasons, Angelus MTA might have been shown more external and internal voids than Biodentine. This result is consistent with a previous study which revealed that Biodentine showed the lowest volume of the gap between the material and the root canal dentin compared to MTA. [14]On the contrary, a μCT study [15] reported that no difference in obturation quality exists between MTA and Biodentine. These controversial results may have been related to the differences in the study designs and the type of materials used.

Filling artificial resorptive cavities with Single cone + Endosequence BC Sealer HiFlow was found significantly better. However, to authors' knowledge until now, no study is available that compared the obturation quality of Single cone + Endosequence BC Sealer HiFlow with CSCs. According to the results of the present study, external as well as internal void percentages for BCHF were significantly lower than MTA and Biodentine. This significant difference can be attributed to the increased flowability of Endosequence BC Sealer HiFlow .

In the present study, the obturation quality was evaluated by measuring external and internal void percentages, separately. The incidence of these voids of root canal fillings can be influenced by several factors, such as the clinician's experience, the selected obturation technique, and the physical properties of the selected materials.[16] The presence of external voids along the dentine walls is an indicator for the assessment of the marginal adaptation of root canal fillings. It has a significant relationship with the outcome of root canal treatment.[17] However, the amount of voids within root canal fillings (internal void) to cause failure in treatment is unclear. Bogen and Kuttler [18] reported that the voids in a calcium silicate-based obturation material do not seem to affect biologic mechanisms necessary for favorable healing. However, it is important to keep in mind that the purpose of the obturation procedures of endodontic treatment is to provide a 3D obturation (without any void) of the whole root canal system to prevent microleakage and reinfection .[19] Further investigations are required in order to evaluate the effect of voids inside the root canal fillings in resorptive cavities obturated with different CSCs on the clinical success of root canal treatment.

CONCLUSIONS

In the present study, none of the filling materials showed void-free obturation. However, a lower void percentage in group 3(Single cone + Endosequence BC Sealer HiFlow), both at the dentin/cement interface and inside the material, may favor its application in IRR over Angelus MTA .

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