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ORIGINAL ARTICLE

The effect of calcium hydroxide on the apical microleakage of canals filled with bioceramic and resin sealers

ABSTRACT

Aim: *To evaluate the impact of calcium hydroxide (Ca[OH]2) on the apical microleakage of canals filled with the bioceramic Total Fill BC (TF BC) and the resin AH 26 sealers.*
Methodology: *A total of 104 human single-canal maxillary teeth were prepared with rotary files. The teeth were randomly divided into two main test groups (n=48) and two control groups, one positive and one negative (n=4). In one test group, $Ca(OH)_2$ was used; in the other test group, no dressing was placed within the canal. Samples in each test group - with or without $Ca(OH)_2$ dressing - were randomly divided into two subgroups. In one subgroup, AH 26 sealer was used and in the other one, TF BC sealer was used. The specimens with $Ca(OH)_2$ were kept at 37 °C in 100% humidity. A dye penetration technique was used to evaluate the leakage. The data were analyzed by Kolmogorov-Smirnov, Kruskal-Wallis, Mann-Whitney U, and Fisher exact tests.*
Results: *The mean microleakage in the subgroups filled with TF BC sealer, with or without $Ca(OH)_2$, was significantly greater than that in the subgroups filled with AH 26 sealer. In addition, the microleakage of the TF BC specimens with $Ca(OH)_2$ was significantly higher than the microleakage of TF BC specimens without the dressing (P<0.001).*
Conclusions: *The findings of this study showed that use of $Ca(OH)_2$ as an intracanal dressing negatively affected the sealing potential of TF BC.*

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Introduction

Bacteria and their products are the main causes of pulpal necrosis and periapical diseases (1). Although chemical and mechanical canal cleaning techniques have been developed over time, none of the current techniques is able to completely clean the root canal system (2). As a solution, studies have suggested the use of an effective intracanal dressing to reduce the number of bacteria in the root canal system (3).

Calcium hydroxide, $Ca(OH)_2$, has commonly been used as an intracanal antimicrobial dressing (4). However, some studies on the removal of intracanal $Ca(OH)_2$ by chemical and mechanical methods have shown that no method is effective at completely removing the dressing (5-7). Incomplete removal of $Ca(OH)_2$ may interfere with the sealing, bonding, and penetration of endodontic sealers, thus negatively affecting the performance of the sealer and possibly impacting the long-term prognosis of root canal treatment (8, 9).

A root canal filling is aimed to prevent reinfection of the canal by providing an adequate seal against bacteria and their toxins (10). Canal filling is done with two materials: a solid core and a sealer (11). Gutta percha is the most commonly accepted solid core root canal filling material to fill the anatomical variations that cannot be cleaned mechanically or chemically (12-14). Various types of sealers, based on zinc oxide, $Ca(OH)_2$, glass ionomer, epoxy resin, silicon, and methacrylate, have been introduced to dentists. In recent years, bioceramic sealers have been introduced to the market. These sealers, according to the manufacturers' claims, are insoluble, radiopaque, aluminum-free, and need water to harden. This type of sealer is hydrophilic and has self-sealing properties owing to its bonding during hardening (15).

The present research was performed to assess the effect of $Ca(OH)_2$ on the microleakage of root canals filled with a new bioceramic sealer, Total Fill BC (TF BC) (FKG Dentaire), and a conventional sealer, AH 26 (Dentsply Sirona).

Materials and Methods

This empirical study was performed on 104 human maxillary single-canal teeth. All the teeth had only one straight canal with no root curvature. The roots were investigated for fractures or cracks by a stereomicroscope (Motic, Xiamen, China) with 40× magnification. Special care was given to ensure the absence of apical and external root resorptions or canal calcification.

To homogenize the specimens, all dental crowns were cut by a diamond disc and a laboratory handpiece so that the length of the remaining root was 15±1 mm. To determine the working length, a No. 20 K-file (Mani, Tochigi, Japan) was placed in the canal until its tip reached the tip of root apex. Then, a rubber stop was placed tangential to the coronal surface of the root, 1 mm was reduced from this length, and the resultant length was recorded as the working length. This length was confirmed with radiographs.

The preparation of each canal was carried out with Mtwo rotary files (VDW, Munich, Germany) up to file No. 40, according to the manufacturer's instructions. The canals were washed with normal saline during preparation.

The teeth were randomly classified into two major test groups (A and B) with 48 specimens in each and four control groups (two positive and two negative) with two specimens in each. A thick $Ca(OH)_2$ paste was prepared with distilled water (3:1 weight ratio of powder to liquid). A No. 30 Lentulo (Medin, Nové Město na Moravě, Czech Republic) and a low-speed handpiece was used to place the $Ca(OH)_2$ paste within the canals of group A and two specimens of each of the positive and negative control groups. No $Ca(OH)_2$ dressing was placed within the canals of group B. Specimens of group B and the four control teeth without $Ca(OH)_2$ were immediately proceeded to the next steps of final rinse and obturation. While specimens of group A and the four control teeth with $Ca(OH)_2$ needed an additional step of 7-day-incubation. The dentinal part of each specimen in

group A and the four control teeth with $Ca(OH)_2$ was temporarily restored to the depth of 3 mm with Cavit (3M ESPE, MN, USA). Then, the specimens were placed first in a closed container in holes created in a saline-soaked sponge and then in an incubator (Memmert, Schwabach, Germany) at 37 °C and 100% humidity. After seven days, the specimens were removed from the incubator, and the $Ca(OH)_2$ paste in the canals was extracted by application of master apical file up to the working length. The canals were then washed with 5 mL each of 5% sodium hypochlorite and 17% ethylenediaminetetraacetic acid solution (Ariadent, Tehran, Iran). This final washing process was also repeated for the specimens in the group B and control specimens without $Ca(OH)_2$ in order to remove the smear layer. A radiograph was obtained from samples with $Ca(OH)_2$ to ensure that the paste has been completely removed from the root canal. Finally, the canals of all the specimens were washed with 5 mL of distilled water and dried with paper points.

The two test groups of A and B - with or without $Ca(OH)_2$ pretreatment, respectively - were divided equally into two subgroups. The canals of 24 specimens pretreated with $Ca(OH)_2$ and 24 specimens without $Ca(OH)_2$, along with two canals in the negative control group - one with and one without $Ca(OH)_2$ - were filled with gutta percha (Gapadent, Tianjin, China) and TF BC sealer by lateral condensation technique. The canals of 24 specimens pretreated with $Ca(OH)_2$ and 24 specimens without $Ca(OH)_2$, along with two canals in the negative control group - one with and one without $Ca(OH)_2$ - were filled with gutta percha and AH 26 sealer using the lateral condensation method. The four specimens of the positive control group - two with and two without $Ca(OH)_2$ - were filled with gutta percha after preparation.

The roots of all specimens except the negative control group were covered with three layers of nail polish up to the apical 2 mm of the root canal. In the negative control group, all root surfaces were covered with nail polish completely. An interval of 24 hours was allowed between the layers of nail polish in order for them to dry completely.

The specimens were then immersed in India ink solution (Pelikan, Hannover, Germany). The height of ink in each container was the same for all specimens to ensure that the hydrostatic pressure of the liquid was equal. To this end, the specimens were immersed in a cryogenic container (Isolab, Bavaria, Germany). After 48 hours, the specimens were removed from the ink and washed with water for 10 minutes.

Afterward, the nail polish was removed from the specimens with acetone. For decalcification, the specimens were put in 10% acid nitric solution (Merck & Co, NJ, USA). The roots were cross-sectioned from the longitudinal direction with a No. 15 scalpel (Aesculap, Tuttlingen, Germany).

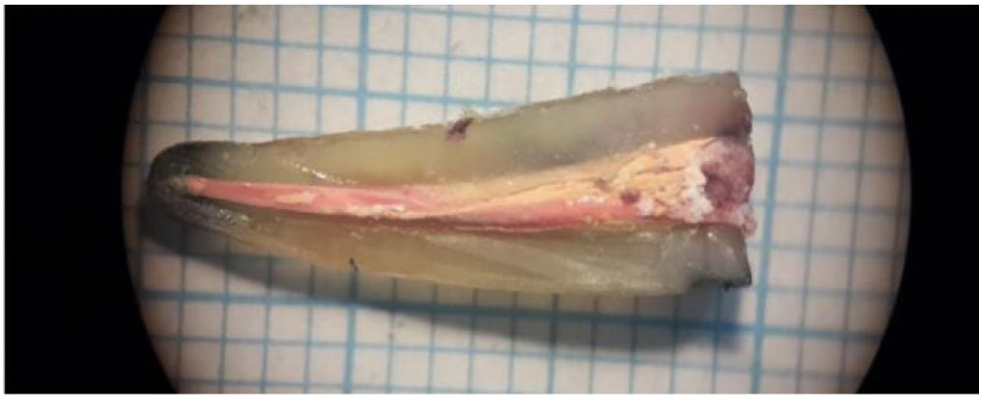

Figure 1.
Demonstration of a sample under microscope.

To determine the penetrability of the dye, prepared sections of specimens were analyzed under stereomicroscope (Figure 1). The maximum level of dye penetration for each specimen was observed under the stereomicroscope with 40× magnification and recorded based on the microscopic scale. All the specimens were investigated by two observers, and the mean of the values obtained for each specimen was considered to be the microleakage of that specimen.
The results were analyzed by SPSS (version 16, IBM Corporation, IL, USA) software using Kolmogorov-Smirnov, Kruskal-Wallis, Mann-Whitney U, and Fisher exact tests. The significance level was set at $P<0.05$.

Results

In the four negative control group specimens, no color penetration was observed. In the four specimens of the positive control group, color penetration was seen all along the canal.
Microleakage was found in 44 AH 26 specimens (91/7%) and 48 TF BC specimens (100.0%). The Fisher exact test revealed that the number of canals exhibiting microleakage did not significantly correlate with the type of sealer ($P=0.117$). The minimum microleakage was found in the AH 26 sealer specimens without $Ca(OH)_2$ paste and the maximum microleakage was reported in the TF BC sealer specimens with $Ca(OH)_2$ paste (Table 1).
The results of the Kolmogorov-Smirnov test showed that the microleakage did not follow a normal distribution pattern ($P=0.038$); therefore, nonparametric tests were used for data analysis. Microleakage in the canals filled with AH 26 and TF BC sealers was reported to be significantly different ($P<0.001$; Mann-Whitney U test). Moreover, the Kruskal-Wallis test showed that the microleakage in the canals with and without Ca(OH)2 and filled with AH 26 and TF BC sealers was significantly different ($P<0.001$). According to the results of Mann-Whitney U test, all binary comparisons of these four groups were significantly different ($P<0.05$).

Discussion

Removal of microorganisms and prevention of reinfection are the major objectives of endodontic treatment, both of which can be achieved by disinfecting and filling the canal space completely. In addition to the cleaning, correct shaping, and sealing of both the root canal and access cavity, intracanal dressings have also been suggested. Although application of $Ca(OH)_2$ has been proposed, currently there is no method available to completely remove it from the canal walls, and the remaining $Ca(OH)_2$ can affect the apical seal of the filled canals. Hence, this study was an attempt to evaluate the effect of $Ca(OH)_2$ on apical microleakage in canals obturated with gutta percha and sealed with AH 26 or TF BC.
The results showed that microleakage was greater in canals filled with TF BC than in canals filled with AH 26. AH 26 is a resin-based sealer that sets quickly. While this sealer has a tendency to exhibit shrinkage and therefore may separate more

Table 1
Mean (SD) microleakage of specimens in the present study

Sealer	Intracanal dressing	Mean (SD) mm
AH 26	$Ca(OH)_2$ paste	3.79 (2.70)
AH 26	None	1.20 (1.64)
TF BC	$Ca(OH)_2$ paste	8.15 (2.51)
TF BC	None	6.10 (2.71)

Abbreviations: $Ca(OH)_2$=calcium hydroxide; TF BC=Total Fill BC.

easily from the canal walls, AH 26 has beneficial factors, such as better penetration into canal irregularities and its ability to creep, which enable it to bond to dentin better than other sealers (16).
TF BC is a calcium silicate-based sealer that has recently been introduced to the market. As mentioned previously, it is a bioceramic sealer that is hydrophilic and expands during setting. This chemical expansion and micromechanical bonding causes the sealer to bond to the canal wall (17, 18). In this type of sealer, hydroxyapatite crystals are formed between the dentin and sealer to the extent that separating these crystals from the dentin walls and dentinal tubules may be challenging (19). It can be hypothesized that the better penetration of AH 26 into a canal compared to TF BC may be the reason for the better sealing potential. The hydroxyapatite crystals formed at the interface of dentin and sealer (20) may result in increased leakage. In addition, since the setting of a bioceramic sealer requires the presence of water (21), drying the canal prior to obturation removes the humidity required for the setting of the sealer, which in turn can explain the increased microleakage.
Kim et al analyzed the impact of $Ca(OH)_2$ and epoxy resin on endodontic retreatment (4). Their findings indicated that the penetration of AH 26 sealer was greater than that of bioceramic sealer, which is in line with the results of the present study. Further, Jafari et al concluded that sealing ability of AH 26 sealers are significantly higher than a bioceramic sealer used in their study (Apatite sealer) (22). However, Mohammadian et al incorporated scanning electron microscopy in order to evaluate the dentin-sealer interface in extracted human single rooted teeth treated using different sealers (23). Their results showed no significant difference in the mean dentin-sealer gap in the coronal, middle, and apical area between AH plus and BC sealer. The inconsistency between findings of the two studies can be attributed to different methods for evaluation of sealing ability.
Moreover, the results of the present study revealed that the amount of microleakage in the canals sealed with TF BC and AH 26 increased in the presence of $Ca(OH)_2$. Due to its alkaline pH, $Ca(OH)_2$ is extensively used for disinfecting root canals. However, it cannot be removed completely from the root canal, which prevents the penetration of sealer into the dentinal tubules of the canal, thereby reducing the adhesion of the sealer to the canal wall. This can cause microleakage in the long term (24).
$Ca(OH)_2$ dressing has shown to have higher microleakage compared to other medications when used with Biodentine plug and gutta percha filling (25). The results of the curent study showed that the number of canals with microleakage with and without $Ca(OH)_2$ was not significantly different.
The present study has some limitations. Micro computed tomography is a better alternative for dye penetration technique. However, dye penetration technique is still used for this purpose. Further studies on new sealers must be performed in order to evaluate the effects of $Ca(OH)_2$ on apical seal.

Conclusions

The findings of this present study showed that $Ca(OH)_2$ as an intracanal dressing affected the sealing ability of the bioceramic sealer TF BC.

Clinical Relevance

Remnants of calcium hydroxide in root canals compromise the sealing ability of TF BC and AH26 sealers.

Conflict of Interest

The authors have no financial, economic, commercial, or professional interests related to topics presented in this article.

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