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Comparative Evaluation of the Effect of Various Irrigating Solutions on the Push-Out Bond Strength of Biodentine and Mineral Trioxide Aggregate: An In Vitro Study

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Abstract

***Introduction*:** A successful endodontic treatment is based on combination of adequate instrumentation, irrigation and obturation of canal system. The objectives of endodontic irrigants are lubrication of root canal, removal of microorganisms, pulp, dentinal remnants and dissolution of tissues. The objective of root-end filling is establishment of proper apical hermetic seal. ***Aim*:** To evaluate and compare the effect of various irrigating solutions on push-out bond strength of Biodentine and Mineral trioxide aggregate (MTA). ***Materials and Method*:** Sixty-four extracted human single rooted teeth were decoronated 1.5-2 mm coronal to cemento-enamel junction. The root canals were prepared and divided into four groups (n=16): Group I- Normal Saline (Control group), Group II- Triple antibiotic solution, Group III- 2% Chlorhexidine, Group IV- Morinda citrifolia solution. Mid root dentin was sectioned horizontally and irrigated further with respective irrigating solutions for 5 minutes and divided into 2 subgroups: Subgroup A- Biodentine and Subgroup B- MTA. The root-end filling material was incrementally placed and embedded in acrylic blocks. Samples were tested for push-out bond strength using universal testing machine. ***Results*:** The highest push-out bond strength was shown by 2% Chlorhexidine group when used with Biodentine and lowest when normal saline was used with Biodentine. ***Conclusion*:** All experimental irrigating solutions increased the push-out bond strength of MTA and Biodentine.

Keywords: Biodentine, Endodontic irrigants, Mineral Trioxide Aggregate, Push-out bond strength, Root-end filling material.

INTRODUCTION

A successful endodontic treatment is based on the combination of adequate instrumentation, irrigation and obturation of the canal system [1]. The ideal irrigating solution should have a sustained effect, low surface tension, low cost, long shelf life without or least affecting the physical properties of the dentin and should not cause irritation to the periapical tissues [2].

Historically, a wide range of filling materials have been used as retrograde fillings including amalgam, modified zinc oxide eugenol-based cements, glass ionomer cements, etc. However, none have been able to satisfy all the requirements of an ideal endodontic repair material [3]. In the recent years, calcium silicate based restorative materials have been introduced like Biodentine and MTA, which have proved to be biocompatible compared to the previous ones [4]. The main objective of a root-end filling is to establish a proper hermetic seal. The adaptation and bond strength between retrograde filling material and dentin plays a vital role and is important for the success of endodontic treatment to withstand and resist the dislodgment forces during function [5].

The most common irrigants are sodium hypochlorite (NaOCl), citric acid, ethylenediaminetetraacetic acid (EDTA), and chlorhexidine (CHX). Irrigation materials cause alterations in the chemical composition of dentine, which may in turn affect the interaction of the root-end filling materials to that of root dentine, thereby interfering with the bond strength to radicular dentin [6].

Therefore, the aim of the present research was to compare the effect of various irrigating solutions on the push-out bond strength of Biodentine and MTA.

MATERIALS AND METHOD

Sixty-four freshly extracted single rooted permanent teeth were collected based on the eligibility criteria.

a) **Inclusion Criteria:** Intact, single rooted teeth with complete root formation, patent canals

b) **Exclusion Criteria:**

Teeth with caries, cracks, restoration, fractures, enamel and dentinal defects, developmental anomalies, erosion, abrasion, open apices, calcified canals and anatomic variations

A. Preparation of Irrigating Solutions

The solutions were freshly prepared at the time of irrigation.

Triple Antibiotic Solution

The TAP is a mixture of ciprofloxacin, metronidazole, and doxycycline. The proportions of the three antibiotics were recommended in a ratio of 1:1:1 by Hoshino E *et al*., [7]. Equal amounts (1:1:1) by weight of Ciprofloxacin injection IP, Metronidazole injection IP and Doxycycline injection USP (lyophilized) were mixed to make the triple antibiotic solution. The prepared formulation was stored in closed container and was used within 24 hours.

Morinda Citrifolia Solution

Morinda citrifolia extract dry powder was thoroughly mixed and shaken manually with deionized water in the concentration of 1:20. The solution was filtered using the Whatman filter paper [8].

B. Preparation of Samples

Disinfected samples were ultrasonic cleaned to remove stains and calculus. Teeth were decoronated 1.5-2 mm coronal to the cemento-enamel junction with a diamond disc. The pulp tissue was extirpated and canal patency was assessed with a size 10 K-file. Working length was established and canals were enlarged up to 25 K-file followed by preparation till F2 Protaper file. The samples were randomly divided according to the irrigating solutions:

Group I- Normal Saline (Control group)
Group II- Triple Antibiotic Solution
Group III- 2% Chlorhexidine
Group IV- Morinda Citrifolia Solution (Indian Mulberry)

Simultaneously, the irrigation was done using the respective irrigating solutions (2.5 ml) after each change of file during the shaping process and recapitulation throughout.

C. Dentin Disk Preparation

The mid-root dentin was sectioned horizontally, perpendicular to the long axis of the teeth into 3mm slices using a water-cooled low speed diamond disc (Figure 1). The specimens were irrigated further with the respective irrigating solutions for 5 minutes and were randomly divided into 2 subgroups.

Subgroup A- Biodentine
Subgroup B- MTA

The test materials were manipulated according to the manufacturer's instructions and incrementally placed and condensed into the canal spaces of the slices. The samples were embedded in acrylic blocks with a central hole to allow the free motion of the plunger (Figure 2). The specimens were placed in an incubator & allowed to set for 48 hours at 37^0C.

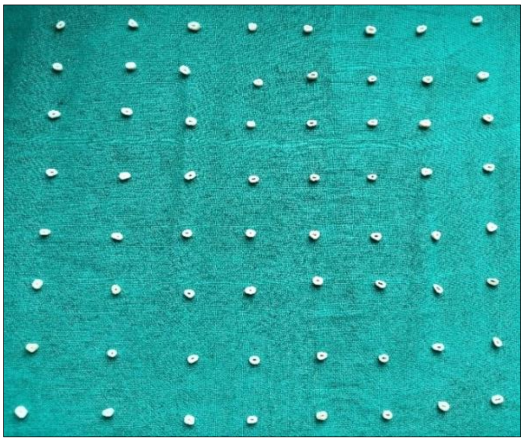

Figure 1: Dentin disk sections

Figure 2: Samples mounted on acrylic resin blocks

D. Push-Out Bond Strength Test

The push-out bond strength values were measured by using universal testing machine. The compressive load was applied by exerting a downward pressure on the surface of the test material with probe moving at a constant speed of 1 mm/min plunger (Figure 3).

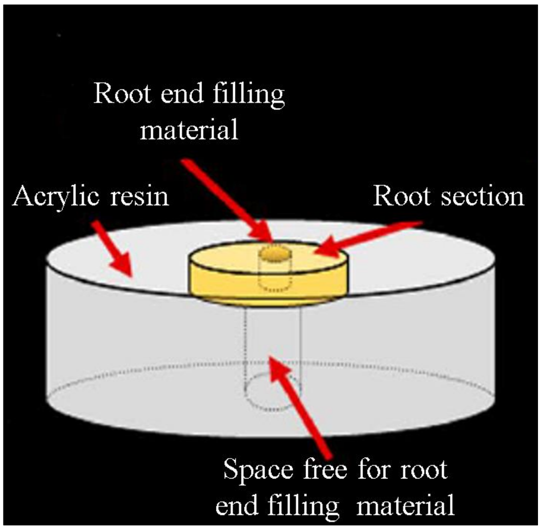

Figure 3: Schematic representation of sample for push out bond strength test

The maximum force applied to materials at the time of dislodgement was recorded in newtons. The push-out bond strength in megapascals (MPa) was calculated by dividing this force by the surface area of test material (N/2 prh), where p is the constant = 3.14, r is the root canal radius, and h is the thickness of the root dentin slice in millimeters. All the data was tabulated and subjected to statistical analysis.

STATISTICAL ANALYSIS

The normality of data was tested by Shapiro Wilk's test and found normally distributed. The means of push-out bond strength (MPa) between groups was tested by one way ANOVA followed by Tukey's HSD test. The tested groups were analyzed using Statistical Package for the Social Sciences (SPSS) software package (SPSS 16 Inc, Chicago IL, USA).

RESULTS

The results revealed that all the experimental irrigating solutions increased the push-out strength of MTA and Biodentine. The tukey HSD test was used for the pairwise comparison of multiple groups [Table 1]. The results were highly significant when 2% Chlorhexidine was used with Biodentine and MTA and in between the Biodentine group when it was used with 2% Chlorhexidine and Morinda citrifolia solution ($p<0.01$).

Table 1: Multiple comparison of means of push-out bond strength (MPa) between two groups by Tukey HSD test showing the significant results

	Mean Difference	Standard Error	p value
Group IA vs Group IIB	-44.4338	7.3583	.000**
Group IA vs Group IIIA	-56.5488	7.3583	.000**
Group IA vs Group IVA	-25.0888	7.3583	.025*
Group IA vs Group IVB	-47.9288	7.3583	.000**
Group IB vs Group IIB	-41.4488	7.1105	.000**
Group IB vs Group IIIA	-53.5637	7.1105	.000**
Group IB vs Group IVB	-44.9438	7.1105	.000**
Group IIA vs Group IIB	-25.3975	7.3583	.022*
Group IIA vs Group IIIA	-37.5125	7.3583	.000**
Group IIA vs Group IVB	-28.8925	7.3583	.005**
Group IIIA vs Group IIIB	35.0888	7.3583	.000**
Group IIIA vs Group IVA	31.4600	7.3583	.002**
Group IIIB vs Group IVB	-26.4688	7.3583	.015*

*Significant $p<0.05$,
**Highly significant $p<0.01$

DISCUSSION

Calcium silicate-based cements are widely used in various endodontic procedures including perforation repair, apexification, apexogenesis, endodontic surgery, and pulpal regeneration [7]. Among the various root-end filling materials tested, MTA has shown good sealing ability and biocompatibility in previous in-vitro and in-vivo studies. The most recently introduced material in the market is e-MTA. It is a bioactive cement containing ultrafine-grained and minute hydrophilic particles of various mineral oxides, hence, has a smooth consistency after mixing. The liquid constitutes of calcium chloride in an aqueous solution with an admixture of polycarboxylate and the setting time is 12 minutes [8]. However, a little information exists with regard to the characteristics of e-MTA including its push-out bond strength, microhardness or fracture resistance. Biodentine is similar to MTA in basic composition, having a reduced setting time [9].

In the present study, following irrigation with saline, MTA was more resistant to dislodgement forces compared to Biodentine, but the difference was non-significant (p>0.05). The push-out bond strength of MTA may be due to the fact that e-MTA contains ultrafine powder particles resulting in better penetration into the root dentine [8]. Also, the saline-treated MTA samples showed slightly better resistance to the dislodgement force as it has remaining unreacted mineral oxides, which may be solidified after additional supplied hydration resulting in increased strength of the material [10].

Similarly, Alsubait *et al*., showed that the push-out bond strength results of Biodentine was very similar to MTA [11]. In contrast to the present study, Ma'atta *et al*., [12] reported that the bond strength of Biodentine was stronger than that of MTA; due to the fact that Biodentine has smaller particle size and better penetrability into the dentinal tubules.

In the present study, on intergroup comparison, the push-out bond strength of both the calcium silicate-based cements were found to be least with normal saline when compared to chlorhexidine, triple antibiotic solution and Morinda citrifolia solution. A plausible reason for the diminished bond strength could be ascribed to the higher amount of remnant of the smear layer, which reduces the area of contact surface at the material-dentine interface and acts as a barrier in the intratubular formation of tag-like structures, which could further impede with the biomineralization process [13].

Chlorhexidine is a synthetic cationic bis-guanide. In the present study, the highest value of the pushout bond strength was found in Group III A, (113.754±15.6063 MPa) in which Biodentine was used as root filling material along with 2% CHX as an irrigating solution and the results were statistically significant (p<0.05). The reason for favourable bond strength might be due its capability to increase surface energy on the dentin, the fact that CHX does not affect the adhesive bond strength between material and dentin and by inhibiting the activity of metalloproteinases on dentin [14]. The current study showed that push-out bond strength of Biodentine was better as compared to MTA which is in accordance with the study conducted by Guneser *et al*., [15], the reason attributed for greater dislodgement resistance of Biodentine was due to the biomineralization ability of Biodentine, as it has higher content of calcium-releasing products which triggers the formation of tag-like structures at cement-dentin interface, also scanning electron microscopic examinations revealed that CHX altered the surface morphology of MTA with the signs of erosion but it could not erode the surface of Biodentine, hence had better push-out bond strength.

On intergroup comparison using Tukey's test, there was no significant difference (p> 0.05) found when Group III B (2% CHX and MTA) was compared to Group I B (Normal saline and MTA), which is similar to study conducted by Sahebi *et al*., [16], that different irrigants (saline and CHX) did not have a significant effect on the push-out bond strength of MTA.

Herbal and natural products of folk medicine have been used for centuries in every culture throughout the world. Morinda citrifolia has a broad range of therapeutic effects, it contains antibacterial components such as lasperuloside and alizarin. Morinda citrifolia juice is one of the first juice to be identified as a possible alternative to the use of NaOCl as an intracanal irrigant [17]. To the best of our knowledge, no studies have been conducted on the effect of Morinda citrifolia solution as an endodontic irrigant on the push-out bond strength of root-end calcium silicate-based cements. In our study, we have used the solution of 6% Morinda citrifolia powder in deionized water as substitute for Morinda citrifolia juice. On the intragroup comparison, that is on using Morinda citrifolia solution as an endodontic irrigant, MTA proved to be better than Biodentine but the difference was statistically non-significant (p>0.05). Yan *et al*., [18], concluded that the push-out bond strength of materials used as root-end fillings was dependent on the irrigating solution in which they were immersed as the irrigating solutions have difference in the pH, their ability to dissolve inorganic materials and capability to remove smear layer which will further affect the bonding of root-end filling material with root canal dentin.

In this study, triple antibiotic solution has been used [Ciprofloxacin injection IP, Metronidazole injection IP and Doxycycline injection USP (lyophilized)] to be employed as an endodontic irrigant. To the best of our knowledge, no studies were found in which triple antibiotic solution in any formulation was used as an irrigating solution to assess the push-out bond strength of root-end filling material, obturation material, endodontic post system or endodontic sealers.

In the present study, the resistance to dislodgement forces of triple antibiotic solution used with MTA was better rather than used with Biodentine ($p<0.05$). This is due to the ultrafine- grained and minute particle size and high flowability of e-MTA as compared to the small particles of Biodentine, which might have enhanced the penetrability of the material into the dentinal tubules, thereby, increasing bond strength. Though the difference was statistically insignificant. Tulumbaci F *et al.*, [19], reported that high push-out bond strength of triple antibiotic paste was due to binding of residual minocycline/doxycycline to calcium via chelation.

CONCLUSION

Within the limitations of this in vitro study, it can be concluded that all the experimental irrigating solutions improved the push-out bond strength of Biodentine and MTA when compared to control group. It can also be inferred that 2% CHX should be used as an irrigating solution when Biodentine is used for perforation repair or as root end filling material whereas on using e-MTA either Morinda citrifolia solution or triple antibiotic solution should be preferred as a good alternative over 2% CHX or normal saline to obtain better results. Further long-term clinical studies are recommended to assess the clinical performance.

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