

Effect of Intracanal Medicaments on the Bond Strength of Bioceramic Root Filling Materials to Oval Canals

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ABSTRACT

Aim: This study aimed to evaluate the effect of the prior application of intracanal medicaments on the bond strength of OrthoMTA (mineral trioxide aggregate) and iRoot SP to the root dentin.

Materials and methods: Thirty single-rooted mandibular premolars were standardized and prepared using ProTaper rotary files. The specimens were divided into a control group and two experimental groups receiving Diapex and Odontopaste medicament, either filled with iRoot SP or OrthoMTA, for 1 week. Each root was sectioned transversally, and the push-out bond strength and failure modes were evaluated. The data were analyzed using Kruskal Wallis and Mann–Whitney *U post hoc* test.

Results: There was no significant difference between the bond strength of iRoot SP and OrthoMTA without medicaments and with the prior placement of Diapex (p value > 0.05). However, iRoot SP showed significantly higher bond strength with the prior placement of Odontopaste (p value < 0.05). Also, there was no association between bond strength of OrthoMTA with or without intracanal medicament (p value > 0.05) and between failure mode and root filling materials (p value > 0.05). The prominent failure mode for all groups was cohesive.

Conclusion: Prior application of Diapex has no effect on the bond strength of iRoot SP and OrthoMTA. However, Odontopaste improved the bond strength of iRoot SP.

Clinical significance: Dislodgment resistance of root canal filling from root dentin could be an indicator of the durability and prognosis of endodontic treated teeth.

Keywords: Bond strength, Diapex, Intracanal medicaments, iRoot SP, Odontopaste.

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INTRODUCTION

The crucial goal of endodontic treatment is preventing and eradicating apical periodontitis,¹ and long-term success of this treatment depends on the level of root canal disinfection as well as proper obturation of the root canal.^{2,3} Gutta-percha in combination with a root canal sealer is the contemporary used obturation materials, although it cannot provide an adequate apical sealing and bonding to the root dentin.⁴

In 2009, a bioceramic OrthoMTA (BioMTA, Seoul, Republic of Korea) was introduced to be used as grafting material to fill the entire root canal without gutta-percha. The manufacturer claimed that OrthoMTA can prevent microleakage by forming an interfacial layer of hydroxyapatite between the material and the dentinal wall.⁵ Furthermore, it has a bioactive feature via releasing calcium ions throughout the apical foramen. It was reported that OrthoMTA contains mainly tricalcium silicate and has less heavy metals.⁶ Moreover, it releases calcium ions that help to persuade regeneration of the periapical tissues. Additionally, its sealing ability is appropriate and comparable to AH Plus/Gutta-percha.⁷

iRoot SP (Innovative Bioceramix, Vancouver, Canada) is another premixed, hydrophilic, injectable bioceramic material composed of calcium silicates, zirconium oxide and calcium hydroxide. The manufacturer claims that iRoot SP has numerous ideal characteristics, including good adhesion, hydrophilic, and osteoconductive, along with its capacity to bond to the radicular dentin chemically.⁸ Furthermore, iRoot SP can be used solitary or in combination with gutta-percha to fill the root canal.

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Disinfection of the root canal is a tedious goal; therefore, association of the mechanical preparation with irrigation solutions and intracanal medicaments was proposed to reduce the infection of the root canal.⁹ Currently, different types of intracanal medicaments are available. Odontopaste® (Australian Dental Manufacturing, Kenmore Hills, Queensland, Australia) is a zinc oxide-based intracanal medicament, and according to the manufacturer, it is composed of a broad-spectrum antibiotic clindamycin hydrochloride, a steroid-based anti-inflammatory agent triamcinolone acetonide and calcium hydroxide. It temporarily reduces inflammation and postoperative pain.¹⁰

Diapex® Plus (DiaDent, Diadent group international, Korea) is a premixed Calcium hydroxide with added Iodoform. Combinations of calcium hydroxide with iodoform have been demonstrated to achieve a wide-spectrum antimicrobial outcome.¹¹ The challenge with the use of intracanal medicaments is the difficulty to remove them completely from the root canal. This could act as a physical barrier between radicular dentin and the material that negatively influence the adhesion and penetration of the filling materials into the dentinal walls.^{12,13} On the contrary, prior placement of intracanal medicaments was demonstrated to enhance the adhesion of the root filling material or have no effect on it.^{13,14}

No abundant information about the effect of these medicaments on the bond strength of bioceramic root filling materials. Therefore, we aimed to evaluate the effect of Diapex and Odontopaste medicaments on the bond strength of OrthoMTA and iRoot SP to root dentin.

MATERIALS AND METHODS

Preparation and Obturation

Thirty single-rooted mandibular premolars that were extracted for orthodontic reasons were used. The teeth without fracture, previous restoration, dental caries, and external resorption were selected and disinfected by using 0.05% of chloramine T-trihydrate. After cleaning the external root surface with ultrasonic scaler, the teeth were radiographed from mesiodistal and buccolingual directs. The teeth that have a ratio of the long to the short canal diameter ≥ 2 were selected to ensure the oval-shaped canal, as it was reported that prevalence of oval canal is common in the human teeth.¹⁵ After that, the teeth were decoronated and the root length was standardized at 16mm. Working length was measured by deducted 1 mm short of apical foramen with K-file (Dentsply Maillefer, Switzerland). All root canals were instrumented using ProTaper universal files (Dentsply Maillefer, Switzerland) until size F3 and irrigated with 5.25% NaOCl throughout preparation. Final irrigation was achieved using 3 mL of 17% EDTA for 1 minute followed by 5 mL of distilled water. The specimens were then randomly divided into three groups ($n = 10$) based on the intracanal medicaments used as follows:

- Group I: No intracanal medicaments (control group).
- Group II: DiaPex® Plus (Calcium hydroxide, Diadent Group International, Korea).
- Group III: Odontopaste® (Australian Dental Manufacturing, Kenmore Hills, Qld, Australia).

All intracanal medicaments were applied according to the manufacturer using a lentulo spiral, and the orifice was sealed using IRM (Dentsply, Caulk, USA). The specimens were incubated for 1 week at 37°C with 100% humidity.

After 1 week, rinsing of the medicaments was done using 10 mL 17% EDTA followed by 10 mL 5.25% NaOCl, and a final irrigation of 5 mL distilled water. After that, the canals were dried using paper points (Dentsply Maillefer). Each group was subdivided into two subgroups based on the assigned root filling materials: iRoot SP and OrthoMTA. The filling materials were according to the manufacturer instructions. Radiographs were taken mesiodistally and buccolingually to confirm complete filling. The orifice was covered with IRM and incubated for 2 weeks at 37°C with 100% humidity to ensure setting of the materials.

Push-out Bond Test

Each root was embedded in cold-cure epoxy resin (Mirapox A and B; Miracon, Malaysia). After setting, the specimen was sectioned transversally using a water-cooled precision diamond saw (Metkon-Micracut 125 low speed precision cutter). The cutting disk was placed perpendicular to the root long axis, and 5 mm from the apex of each root was discarded due to the small size of the filling material and the possibility of round cross-section of the root canal in this level. The rest of the root was cut to obtain 5 root slices ($n = 25$ sections/group) with $1 \text{ mm} \pm 0.01$ thickness. For accuracy of the calculation, the thickness of each slice was gauged using a digital calliper (Mitutoyo/ Digimatic, Tokyo, Japan).

Universal testing machine (UTM) (Shimadzu, Japan) was used to assess the push out bond force. A 0.6 mm diameter cylindrical stainless-steel plunger was equipped in the UTM. Each specimen was positioned in a customized fabricated jig to fix and align in a way that the apical surface faced the plunger. The filling material only was in contact with the plunger to prevent misreading by fracture of the root dentin. An increasing compressive load was applied at a crosshead speed of 0.5 mm/minute until bond failure occurred. The bond failure load (N) was recorded at the point where a sharp drop of the stress-strain curve was observed, and complete dislocation of the root filling material had occurred. The bond strength (MPa) was calculated by dividing the force (N) by the root canal filling bonding area (mm^2). The bonding area of oval canal was calculated as described previously.¹⁶

Failure Mode

The specimens were then checked under a stereomicroscope at 40× magnification to describe the bond failure mode. The interface area between filling materials and dentin wall was classified into three failure modes according to the measurement of the residual filling material percentage as follows: < 25%—adhesive, >25% to <75%—mixed, and >75%—cohesive.¹⁷

Statistical Analysis

Data were analyzed using SPSS software version 12 (Chicago, USA). Kruskal Wallis and Mann–Whitney *Post hoc* tests were performed to detect the variance among intracanal medicaments and control for each filling materials. Multiple Mann–Whitney tests were carried out to detect the difference between two root filling materials for each intracanal medicaments used and control separately. The association between failure modes and root filling was analyzed using Chi-square test. *p* value was set at 0.05.

RESULTS

The mean of push-out bond strength of all groups is presented in Table 1. Mann–Whitney test showed there was no significant difference between bond strength of iRoot SP and OrthoMTA

Table 1: The mean push-out bond strength (MPa) of the bioceramic root filling materials

Intracanal medicaments	iRoot SP (mean \pm SD)	OrthoMTA (mean \pm SD)	<i>p</i> value
No medicament (control)	2.62 \pm 1.04	4.16 \pm 3.41	0.260
Diapex plus	5.47 \pm 6.44	3.49 \pm 3.74	0.299
Odontopaste	9.68 \pm 5.71	4.98 \pm 5.27	0.003*
<i>p</i> value	< 0.001	0.536	

*Significant difference $p < 0.05$

Table 2: Frequencies of failure modes among the bioceramic root filling materials

Root filling materials	Adhesive (%)	Cohesive (%)	Mixed (%)
No medicaments with OrthoMTA	9 (36)	12 (48.0)	4 (16)
No medicaments with iRoot SP	2 (8)	14 (56)	9 (36)
Calcium hydroxide with OrthoMTA	5 (20)	15 (60)	5 (20)
Calcium hydroxide with iRoot SP	7 (28)	13 (52)	5 (20)
Odontopaste with OrthoMTA	5 (20)	15 (60)	5 (20)
Odontopaste with iRoot SP	4 (16)	15 (60)	6 (24)

in control and Diapex groups (p value > 0.05). However, iRoot SP showed significant higher bond strength than OrthoMTA in Odontopaste group (p value < 0.05). Kruskal-Wallis test and Mann-Whitney *Post hoc* showed there was no significant difference in bond strength of OrthoMTA with or without intracanal medicament (p value > 0.05). Nevertheless, iRoot SP showed a significant increase in bond strength with prior application of Odontopaste compared to Diapex and control groups. The frequency of failure mode is shown in Table 2. Chi-square test demonstrated no association between failure mode and root filling materials, p value = 0.138. The prominent failure mode for all groups was cohesive.

DISCUSSION

Dislodgment resistance of root canal filling from root dentin could be an indicator of the durability and prognosis of endodontic treated teeth. The bond strength of root canal filling materials is affected by different factors, including anatomy of the root canal,¹⁸ the prior placement of intracanal medicaments, obturation materials and techniques, slice thickness, and final irrigation protocol.^{19–21} The material with the higher dislodgment resistance from root dentin maintains the root filling–dentin interface integrity during tooth flexure and the preparation of post spaces.¹⁸

The push-out test is one of the tests to measure the bond strength, and it is considered a true shear test for parallel-sided samples because the dislocation occurs parallel to the dentine–material interface.²² It has been mostly used to evaluate the effectiveness of the dislodgment resistance of dental materials.^{19–21} Although there was considerable variation in the push-out test used in laboratory studies,²³ the push-out test is not strongly influenced by these variables and seems to be suitable for ranking root filling materials.²⁴ The push-out test is considered a reliable method to measure the root canal filling materials bond strength.²⁵ It is less sensitive to small discrepancies among specimens and to differences in stress distribution during application of the load compared to shear strength test, and it is also easy to align specimens for testing.²⁶

In the current study, prior placement of Diapex had no effect on push-out bond of OrthoMTA, and this is consistent with previous study that reported the dislodgment resistance of bioceramic root canal fillings had not significantly affected by the use or absence of medicaments.²⁷ Conversely, prior placement of Diapex improved insignificantly the bond strength of iRoot SP, and this is in agreement with previous researchers who demonstrated that prior

placement of water-based calcium hydroxide medicament seemed to enhance the dislodgment resistance of iRoot SP. This finding was attributed to the chemical interaction of calcium hydroxide residues with iRoot SP that could increase the dislodgment resistance and the micromechanical retention of the filling material.¹⁴

Unlike water-based calcium hydroxide, Diapex is oil-based calcium hydroxide that might not well contact the root canal walls due to the large contact angles and therefore can be removed more efficiently and easily from the canal walls.²¹ Consequentially, fewer residues of calcium hydroxide may interact chemically with iRoot SP that explained the nonsignificant increase in the bond strength of iRoot SP. Conversely, prior placement of Odontopaste enhanced the dislocation resistance of iRoot SP. There was no literature on the effect of prior placement of Odontopaste on different root filling materials. However, Odontopaste composed mainly of zinc oxide with addition of antibiotics, and zinc oxide inhibits the dentin demineralization and that may consequently enhance the bond strength of root filling material to dentinal wall by providing more mineralized dentin for hybridization.^{28,29} Hybridization is the most widely applied mechanism of adhesion of dental materials to dentin. It involves the formation of hybrid layer as a result of demineralization of dentine and expose of collagen fibers that is followed by micromechanical interlocking of root canal sealer or filling components into the collagen matrix in the intertubular dentine.³⁰

Both OrthoMTA and iRoot SP can bond to the dentin chemically and mechanically by forming an interfacial layer of tag-like structures containing apatite-like precipitates. The particles in this interfacial hybrid layer can penetrate the dentinal tubules and intratubular mineralization forming interlocking.⁷ However, their bonding to root dentin was affected contrarily by prior placement of intracanal medicaments, and the explanation of this could be attributed to the differences in the particle size and the flow rate of both materials. iRoot SP has a good flow value which is more than 23 mm. Flow rate of orthoMTA is not reported in the literature; however, it was demonstrated to have similar chemical composition and morphological characteristics to ProRoot MTA.³¹ Hence, it may have similar flow rate which is 14.2 mm.³²

Premolars with oval canal specimens were used in this study, and it was established that preparation and obturation of oval canals is a difficult task and the quality of obturation depends considerable on the flow of root filling materials to unprepared recesses of the canal.³³ The good flow rate of iRoot effect positively on the filling quality of the oval canal and subsequently enhances the bond strength. In the current study, the bond failure mode was mainly cohesive for all groups. This outcome is in accordance with previous studies.¹⁸ This was associated with the improved bond strength of sealer to root dentin and consequently decreased the sealer–dentin interface disruption and increases the probability that failure will occur within the sealer itself.³⁴ One of the limitations of this study are the difficulty to standardize the specimens due to the variations in human root canal anatomy. Push-out test was used in this study, thus, using another test may lead to different results. Whilst present data is only based on *in vitro* study, the result may vary *in vivo* conditions.

CONCLUSION

With the limitation of the study mentioned earlier, it can be concluded that prior application of Diapex has no effect on bond strength of OrthoMTA and iRoot SP. Meanwhile, prior placement

of Odontopaste increases the iRoot SP bond strength and has no effect on that of OrthoMTA.

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