Effect of triple antibiotic paste on the bond strength of epoxy and methacrylate resin-based sealers to root canal dentin

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Abstract

Purpose: This study aimed to evaluate the effect of triple antibiotic paste (TAP) as an endodontic intracanal medicament on the bond strength of epoxy and methacrylate resin-based sealers to root canal dentin.

Materials and Methods: In this in vitro study, 80 single-rooted human mandibular premolars were prepared using ProTaper rotary system. The specimens were randomly divided into a control group (without intracanal dressing) and an experimental group receiving TAP (n = 40). The intracanal dressing was removed after 3 weeks. Then, samples of each group were randomly divided into four subgroups (n = 10) and obturated with gutta-percha and different resin-based sealers. G1: AH Plus, G2: Syntex, G3: EndoREZ, and G4: MetaSEAL. After 1 week, 16 slices of 1 ± 0.1 mm thickness were obtained from the midroots of teeth in each subgroup, and a push-out test was used to measure the bond strength. Slices were examined using a stereomicroscope at 30 × to determine the mode of failure. The data were analyzed using two-way analysis of variance, one-way analysis of variance, and Tukey post hoc tests (α = 0.05).

Results: Compared to control group, TAP significantly increased the bond strength of MetaSEAL and EndoREZ (P < 0.05). In the control group, epoxy resin-based sealers showed higher bond strength compared to methacrylate ones (P = 0.00). In TAP group, Syntex and EndoREZ showed significantly the greatest and the lowest bond strengths, respectively, (P < 0.05). The analysis of failure modes revealed a predominance of mixed failures in all groups except for Syntex group in which most failures were cohesive.

Conclusions: TAP significantly increased the bond strength of methacrylate resin-based sealers.

Keywords: AH plus; bond strength; EndoREZ; MetaSEAL; Syntex; triple antibiotic paste

INTRODUCTION

Complete eradication of microorganisms and their byproducts from the root canal system is impossible even after chemomechanical preparation in any form.¹ Therefore, application of intracanal medicaments has been suggested for further reduction of bacterial load.²³ Calcium hydroxide (CH) is the most commonly used intracanal medicament due to its antibacterial and anti-inflammatory effects, and ability to dissolve remnants of pulpal tissue.⁴ However, some deficits such as inability in the elimination of Enterococcus Faecalis⁵ and being potentially toxic due to its high pH makes investigators to search for new therapeutic agents to be used as alternative intracanal medicaments.⁵ Due to polymicrobial nature of endodontic infections, a mixture of different antibiotics has also been proposed as potential intracanal medicaments.⁶

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Triple antibiotic paste (TAP), consisting of metronidazole, ciprofloxacin, and minocycline, is used in endodontics not only in the regeneration and revascularization protocol of the pulp but also for the treatment of periapical lesions, external inflammatory root resorption, root fracture, and primary teeth.\(^7\)

This endodontic medicament has been found to have excellent antimicrobial properties and to be biocompatible.\(^8,9\) Studies demonstrated that the use of TAP as an intracanal medicament increased the dentinal tubule disinfection\(^10\) and penetration area of the medicament\(^11\) compared with CH.

Despite of all favorable characteristic of TAP, similar to other intracanal medicaments, it cannot be completely cleaned from the root canal.\(^12,13\) Moreover, it has been showed that TAP changes the chemical structure of dentin.\(^14,15\) Therefore, in teeth treated with this medicament, the bonding of endodontic sealers to radicular dentin may be affected. Nevertheless, limited studies have been published concerning the impact of TAP on the bond strength of resin-based sealers to root dentin.

In one study conducted by Akcay \textit{et al.}, pretreatment with TAP enhanced the bond strength of AH Plus, an epoxy resin-based sealer, to the root canal dentin.\(^16\) However, this study suffers from the fact that only one endodontic sealer was evaluated. Moreover, to the best of our knowledge, there are no data regarding the effect of pretreatment with TAP on the adherence of methacrylate resin-based sealers to the radicular dentin. Therefore, the aim of the present study was to evaluate and compare the effect of pretreatment with TAP on the bond strength of two epoxy (AH Plus and Syntex) and two methacrylate (EndoREZ and MetaSEAL) resin-based sealers.

**MATERIALS AND METHODS**

The study was approved by the Ethics Committee of the Shiraz University of Medical Sciences (REC.1396.S94). All methods were carried out in accordance with relevant guidelines and regulations.

Eighty human mandibular premolar teeth extracted for clinical reasons with the patients` informed consent were used in this study. A buccolingual radiograph was taken for each tooth to ensure the presence of a single canal. Exclusion criteria were open apices, resorptions, cracks, or previous root canal treatments.

The teeth were disinfected by immersion in 0.5% chloramines T solution for 48 h and then kept in distilled water until use.

Each tooth was decoronated to obtain a standardized root length of 15 mm. Working length was established by subtracting 1 mm from length of a size 10 K-file that its tip was visible at the apical foramen. Cleaning and shaping were done using ProTaper rotary files (Dentsply Maillefer) up to size F4 (#40/0.06). Irrigation with 2 mL of 2.5% sodium hypochlorite (Chloraxid, Cerkamed, Poland) was performed before using each file.

At the end of preparation, each canal was rinsed with 5 mL 17% EDTA and 5 mL 1% NaOCl each for 1 min, and dried. At this stage, the specimens were randomly allocated into a control group of no intracanal medicament \((n = 40)\) and an experimental group receiving TAP as intracanal medicament \((n = 40)\). TAP was prepared by taking equal amounts of powdered metronidazole (Metromax, Tehran Chemie, Tehran, Iran), ciprofloxacin (Cipro, Tehran Darou Co., Tehran), and minocycline (Minocin, Watson Pharmaceuticals Inc., California, USA) and mixing them with sterilized distilled water in a powder/liquid ratio of 3:1.

Lentulo spirals number 40 were used to transferred the prepared paste into the root canals. Then, the coronal openings were temporarily sealed with a cotton pellet and temporary restorative material (Cavisol, Golchai Co., Iran), and the samples were kept in an incubator at 37°C in 100% humidity for 21 days.\(^17\) At the end of incubation period, TAP was removed by needle irrigation of canals with 10 ml 17% EDTA, followed by 10 mL 2.5% NaOCl\(^12\) and a final flush of 5-mL distilled water. In the next step, the samples of both control group and experimental group were divided into four subgroups based on the sealers used for obturation of the root canals. Two epoxy resin-based sealers: G1: AH Plus (Dentsply DeTrey, Konstanz, Germany) and G2: Syntex (Cerkamed, Stalowa Wola, Poland) and two methacrylate resin-based sealers: G3: EndoREZ (Ultradent, South Jordan, Utah, USA) and G4: MetaSEAL (Parkell Inc, Edgewood, NY) were used.

Obturation in all groups was performed by a single-cone technique with use of F4 gutta-percha cones combined with one of tested sealers. The F4 gutta-percha cones (Dentsply Maillefer, Ballaigues, Switzerland) were coated with respected sealers and inserted into the root canal up to the working length. The excess gutta-percha and sealer in the coronal portion were removed, and in the methacrylate resin-based sealer groups (G3, G4), the coronal surface was light cured for 40 s.

After that, the coronal openings were sealed with a temporary filling material, and the specimens were stored for 1 week at 37°C and 100% humidity to allow the sealers to set. Each root was then sectioned perpendicular to its long axis using a low speed saw (Mecatom T180; Presi SA, Angonnes, France) under continuous water irrigation. Two slices \((1 \pm 0.1\) mm thick\) were obtained from the midroot.
of each tooth (n = 20). The slices were checked under a stereomicroscope, and finally, 16 discs with round lumen were chosen from each subgroup.

A digital camera attached to a stereomicroscopic (Bestscope-3060c, China) was used to capture images from coronal and apical aspects of each slice under 32× magnification. Scopeimagesoftware(Bestscope-3060c, China) was then used to measure the lumen diameters of both sides of the slices.

A universal testing machine (ZwickRoell, Z050; ZwickRoell, Ulm, Germany) was used for the push-out bond strength test, at a crosshead speed of 1 mm/min and with a 0.5-mm diameter cylindrical plunge. Loading was performed in an apical-coronal direction until the displacement of the filling material. The maximum load before failure was recorded in newton and divided by the adhesion area, resulting in a bond strength expression in mega Pascal (MPa).

The adhesion area of the root canal filling was calculated using the following formula:

$$\pi (R + r) [h^2 + (R - r)^2]^{0.5}$$

where π is the constant 3.14, R is the radius of the coronal side, r is the radius of the apical side, and h represents the thickness of the root slice.\(^{[18]}\)

After the test procedure, the specimens were observed under a stereomicroscope at 32× magnification to determine the mode of failure. Three types of failure were categorized: adhesive failure (at the sealer dentin interface), cohesive fracture (within the filing material or dentin), and mixed failure (a mixture of cohesive and adhesive failures).\(^{[19]}\)

**Statistical analysis**

The data were analyzed using two-way analysis of variance. As there was a significant interaction effect between using TAP and the root canal sealers, one-way analysis of variance and post hoc Tukey’s tests were used to detect the effect of the independent variables (using TAP and sealers) on the bond strength. All statistical analyses were done using SPSS (version 20, SPSS Inc., Chicago, IL, USA) at a significance level of 0.05.

**RESULTS**

A significant interaction effect was found between sealer types and using TAP (P < 0.05).

The mean and standard deviation of the push-out bond strength values (MPa) of the sealers to the radicular dentin are indicated in Table 1.

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**Table 1: Mean±standard deviation of push-out bond strength values**

|                | AH Plus          | Syntex          | EndoREZ          | MetaSEAL         |
|----------------|------------------|-----------------|------------------|------------------|
| Control        | 3.68±1.14\(^{a}\) | 3.86±2.54\(^{a}\) | 0.6±0.69\(^{a}\) | 0.96±0.82\(^{a}\) |
| TAP            | 3.92±1.04\(^{a}\) | 3.53±1.96\(^{a}\) | 1.51±1.35\(^{a}\) | 3.79±1.05\(^{a}\) |

The same lowercase letters (row) and uppercase letters (column) are not significantly different. TAP: Triple antibiotic paste

Compared to control group, TAP significantly increased the bond strength of methacrylate resin-based sealers (P = 0.0001 and P = 0.002 for MetaSEAL and EndoREZ, respectively). In epoxy resin-based sealers (AH Plus and Syntex), the increase in the bond strength was not significant (P > 0.05).

In the control group, the epoxy resin-based sealers showed significantly higher bond strength compared to the methacrylate resin-based sealers (P = 0.0001). In the TAP group, the greatest and the lowest bond strengths were belonged to Syntex and EndoREZ, respectively, which were significantly different from other sealers (P < .05).

The analysis of failure modes showed a predominance of mixed failure in all groups with the exception of Syntex group in which most failures were cohesive.

**DISCUSSION**

Adhesion of endodontic sealers to intraradicular dentin is an important property for two main reasons. In a static situation, it prevents the passage of fluids between the filing material and the radicular dentin.\(^{[20]}\) In a dynamic situation, it minimizes the risk of dislodgment of root canal filing material during the restorative procedures or masticatory function.\(^{[21,22]}\) Actually, it has been reported that sealing ability and bond strength of endodontic sealers may strongly correlate with each other.\(^{[23]}\)

According to the result of the present study, TAP increased the bond strength of all tested resin-based sealers. However, the increase was statistically significant only for the methacrylate resin-based sealers.

Our findings are partly in accordance with those of Akçay et al.\(^{[14]}\) who evaluated the effects of CH, TAP, and double antibiotic paste (DAP) on the bond strength of an epoxy resin-based sealer (AH Plus) to the radicular dentin. They reported higher bond strength in the TAP group, whereas DAP and CH did not show any promising effect. The authors\(^{[15]}\) attributed their finding to the binding of residual minocycline to the calcium ions of dentinal walls through a chelation reaction. Although this theory may explain the incomplete removal of TAP from the root canals, we believe it does not clarify how the tested sealer bonded to the residual of TAP and in this way to the dentinal wall.
In our opinion, the increase of the bond strength of resin-based sealers to dentin after application of TAP could be attributed to the strong demineralizing and erosive effect of this medicament on the radicular dentin due to its low pH value. This erosive effect increases the adhesion surfaces, which in turn may improve the adhesion of sealers to dentin. Further studies are recommended to assess the changes in the topography of dentin after application of TAP. In addition, a decline in the phosphate/amide I ratio has been reported after treatment of dentin with TAP. This chemical change may also have a promising effect on the bond strength of resin-based sealers to dentin. More investigations are needed to verify these theories.

In another study, Shakouie et al. concluded that the effect of TAP on the bond strength of endodontic sealers was not negative. However, as their study had no control (no medicament) group, its comparison with the current study seems not to be logical.

On the other hand, in the study of Arslan et al., TAP decreased the bond strength of a self-adhesive resin cement (RelyX U200; 3M ESPE, Seefeld, Germany) to the root dentin. As normally the acid groups of this cement chemically interact with calcium ions of hydroxyapatite crystals, the authors discussed that the bonding strength would be adversely affected because the calcium ions had been previously chelated by minocycline. The authors also mentioned that the incomplete removal of TAP from the canal walls could be another possible reason for the decrease of bond strength. The discrepancy between the results of Arslan et al. and the present study could be attributed to the different types of material used (resin cement versus resin sealers) and different protocols used for removal of TAP.

The result of the present study showed that in the control group, both epoxy resin-based sealers presented significantly higher bond strength than both of methacrylate resin-based sealers. This finding is in agreement with the result of previous studies comparing the bond strength of these two subgroups of resin-based sealers.

The stronger adhesion of epoxy resin-based sealers has been attributed to the lower volumetric polymerization shrinkage and higher penetration to the dentinal tubules.

In the current study, Syntex showed the maximum bond strength both in control and in TAP groups. Its difference was even significant with AH, another epoxy based sealer, in TAP group. Syntex is a new epoxy resin-based sealer that according to its manufacturer has minimal shrinkage upon setting, particles of the smallest possible size, and excellent penetration properties. These features can explain the good adhesion of this sealer found in the current study. In addition, evaluation of the root dicks after the push-out test demonstrated a predominance of cohesive failure for Syntex but mixed failure for other groups, which confirms the better adhesive performance of this new epoxy resin-based sealer.

**CONCLUSIONS**

Under the limitation of this in vitro study, it can be concluded that TAP improved the bond strength of the methacrylate resin-based sealers.

**Data availability**

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

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**Conflicts of interest**

There are no conflicts of interest.

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