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Effect of intracanal medicament on bond strength of fibre posts

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ABSTRACT

The aim of this study was to evaluate the effect of calcium hydroxide (CH), triple antibiotic paste (TAP) and double antibiotic paste (DAP) on the push-out bond strengths of three different self-adhesive resin cements. Forty-eight single-rooted human maxillary central incisors were selected. The crowns were removed and the root canals were performed. After the irrigation protocols, the post space was prepared. The teeth were then randomly divided into a control group (no intracanal medicament) and three medicament groups ($n = 12$ for each group). After three weeks, the medicaments were removed using 17% ethylenediaminetetraacetic acid, 2.5% sodium hypochlorite and EndoActivator agitation. The teeth were divided into three subgroups according to the fibre-post luting cement: Maxcem Elite, RelyX Unicem and BisCem. The specimens were sectioned and the push-out test was performed. One-way analysis of variance and Tukey's *post hoc* tests were used for statistical analyses. Regarding the type of cement, BisCem had significantly lower bond strength values than Maxcem and RelyX. There was no significant difference between the bond strength values of Maxcem and RelyX ($p > 0.05$). The TAP-RelyX group had the highest bond strength value and the DAP-BisCem group had the lowest bond strength value. RelyX and Maxcem had higher bond strength to root canal dentin than BisCem. The bond strength of BisCem, RelyX and Maxcem was not negatively affected by the use of DAP, CH and TAP as intracanal medicaments.

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Introduction

After root canal treatment, the teeth become weakened due to structural loss that results from canal preparation or extensive previous restoration.[1,2] That is why they require specialized restoration materials.[3] The use of intracanal posts, especially fibre posts, promotes both the retention of the final restoration and the strengthening of the remaining tooth structure.[1,4] The elasticity of the fibre post is very similar to dentine, and because of this, prevents vertical fracture risk by distributing the stress from the canal walls.[4,5]

Conventional (zinc phosphate or glass-ionomer cement) and other adhesive cements (etch-and-rinse and self-etch), along with different luting systems (self-cured, light cured and dual cured) are used for fibre-post luting.[6–8] Conventional resin cements require the use of an acid etching, primer or adhesive before bonding the fibre post. However, this complicated multi-stage application technique may disrupt the bonding effectiveness.[9,10] Therefore, self-adhesive dual cure resin cements, such as RelyX Unicem (3M ESPE, St Paul, MN, USA), BisCem (Bisco, Schaumburg, IL, USA) and Maxcem Elite (Kerr, Orange, CA, USA) combine this multi-stage application.[9] These systems mean less chair-side time and greater ease of use.[11] The adhesive properties of these systems are known to be based upon acidic monomers. Micromechanical retention and chemical adhesion of the self-adhesive systems to tooth structure were formed by demineralizing of the acidic monomers.[12] According to Goracci et al., [13] dual-polymerized luting agents have superior mechanical properties and are the most confident choice for the cementation of fibre posts.

However, post debonding is the most common complication of canal-post applications.[14] The pre-treatment of the dentin surface, form and structure of the post, and the selection of the luting system may affect the bonding properties of fibre posts in the root canal dentin.[15,16]

There are different intracanal medicaments used for disinfection of the root canal. Calcium hydroxide (CH) has been widely preferred because of its antimicrobial efficacy and its biocompatibility.[17,18] However, some cases of failure treated with calcium hydroxide and regenerative endodontic treatments have shown

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successful results with triple antibiotic paste (TAP), which consists of a mixture of ciprofloxacin, metronidazole and minocycline.[19–23] Despite these positive features, several case reports have shown that minocycline causes visible crown discoloration.[24,25] The use of double antibiotic paste (DAP), which is a combination of metronidazole and ciprofloxacin, is suggested to overcome the discoloration problem associated with the minocycline in TAP.[26,27]

It is not possible to remove the canal medicaments completely from the root canal,[28,29] and residual medicaments on the root canal walls have been shown in many studies to affect the bond strength, apical leakage and the penetration of sealers into dentinal tubules.[30–32] Nevertheless, there is limited data about the effect of residual medicaments on adhesion of the fibre posts to the dentin walls. Only a few studies have reported that the bond strength of the fibre post is affected by CH dressing.[9]

To the best of our knowledge, the influence of antibiotic pastes on the bond strength of self-adhesive dual cure resin to the root canal has not yet been evaluated. Therefore, the aim of the present study was to evaluate the effect of calcium hydroxide (CH), TAP and DAP on the push-out bond strength of RelyX, BisCem and Maxcem self-adhesive resin cements (SARCs). The null hypothesis was that there would be no differences among the groups.

Materials and methods

The study design was approved by the Tokat Clinical Research Ethics Committee of the Gaziosmanpaşa University of Turkey (15-KAEK-058). Forty-eight single-rooted human maxillary central incisors which had recently been extracted for periodontal reasons were selected and stored in 0.1% thymol until use. The teeth were carefully examined under an operating microscope (Zeiss, Oberkochen, Germany) with a 20× magnification. Teeth with immature apices, caries or restorations, fractures or cracks were excluded from the study. To ensure standardization, teeth crowns were removed to achieve a standard length of 16 mm for each tooth. Reciproc R40 instruments (VDW, Munich, Germany) were used for root canal preparation. One operator completed all root canal instrumentations. Irrigation was performed with 1 mL of 2.5% NaOCl between three pecking sequences and following instrumentation, root canals were irrigated with 5 mL of 2.5% NaOCl as a final rinse.

The root canals were enlarged with post drills (Glassix, Harald Nordin SA, Chailly-Montreux, Switzerland) to form a 10 mm depth and 1.5 mm diameter of the post space. Five millilitres of 2.5% NaOCl and 5 mL of 17% ethylenediaminetetraacetic acid (EDTA) solution were performed in the post space. The final flush was made with 5 mL of distilled water and dried by using paper points. Root canal filling was not applied to the gap between the cement paste with the post-preparation in the analysis of adhesion as described by Renovato et al. [33] The teeth were then randomly divided into a control group ($n = 12$) (no intracanal medication) and three experimental groups ($n = 12$ per group) as follows: (1) Calcium hydroxide: $Ca(OH)_2$ powder (Kalsin; Aktu Ticaret, İzmir, Turkey) was mixed with distilled water; (2) DAP was prepared by mixing antibiotic powders compounded of equal portions of metronidazole and ciprofloxacin with distilled water; (3) TAP was prepared by mixing antibiotic powders compounded of equal portions of metronidazole, ciprofloxacin and minocycline with distilled water and (4) control: no medicament.

The powder-to-liquid ratio of the pastes was 3:1. The medicaments were packed into the root canals with a size #40 Lentulo. The temporary filling material (Cavit; 3M ESPE, Seefeld, Germany) was used to seal the coronal portions of the root canals. The samples were stored at 37 °C in 100% humidity for three weeks. After three weeks, the medicaments were removed by rinsing with 5 mL of 17% EDTA, followed by 5 mL of 2.5% sodium hypochlorite and a final irrigation with 5 mL of distilled water.

After each irrigation procedure, the EndoActivator was placed into the root canal and activated at a power setting of three for 1 min. Canal spaces were dried using absorbent paper points. The samples were divided into three subgroups (Maxcem Elite, RelyX Unicem and BisCem dual cure resin cement). The fibre posts (Glassix, Nordin, Swiss Dental Products.) of 1.5 mm in diameter were cemented using Maxcem Elite, RelyX Unicem and BisCem dual cure resin cements. They were light cured only at the top surface for 40 s. The roots were then placed in 100% relative humidity at 37 °C for one week.

Each of the samples was embedded into acrylic resin and the vertical angulations of fibre posts were checked for push-out bond testing. Then, they were sectioned perpendicular to the long post axis into six slices approximately 1 mm thick by using a diamond saw (Microcut 200, Metcon, Turkey).

The push-out test was applied using a universal testing machine (Instron Corp, Norwood, MA, USA). A cylindrical plugger was used with a continuous load to each specimen. A 0.5 mm min^{-1} crosshead loading speed was applied until bond failure occurred. Before the dislodgement occurred, the maximum load applied was recorded in Newtons and converted to megapascals

(MPa) according to the following formula:

$$\text{Push out bond strength (MPa)} = \frac{F\text{-max (N)}}{\text{adhesion surface area (mm}^2\text{)}}$$

The adhesion surface area of each sample was calculated as follows:

$$\text{Adhesion surface area (mm}^2\text{)} = \left(\frac{R_1 + R_2}{2}\right) \times \pi \times h$$

where R_1 and R_2 are the upper and lower post space diameters ($R_1 = R_2 = 1.5$ mm), respectively; π is the constant 3.14 and h is the thickness of filled root samples (1 mm).

After the push-out test, samples were examined under a stereomicroscope (Zeiss, Oberkochen, Germany) at 25× magnification for failure modes. The failures were classified according to Teixeira et al. as (1) adhesive in dentine – cement was totally separated from dentine; (2) adhesive in the post – cement was totally separated from post; (3) mixed – a mixture of adhesive in dentine and post failure; (4) cohesive – the fracture occurred only on the post or dentine. Bond failure sites were not statistically analysed.[34]

The data were statistically analysed using one-way analysis of variance and Tukey's *post hoc* tests. All statistical analyses were performed using IBM SPSS, Ver. 20.0 software (IBM SPSS, Inc. Chicago, IL, USA). The significance level was set at $p = 0.05$.

Results and discussion

Endodontic biomaterials should adhere to the dentine wall and provide resistance of the materials during function.[35] These features can be evaluated *in vitro* in terms of bond strength.[36] The bond strength of the fibre posts to the dentin walls is influenced by the various luting systems.[6]

The mean push-out bond strength values obtained in this study are presented in Table 1. Regarding the type of cement, BisCem had significantly lower bond strength values than Maxcem and RelyX. There was no significant difference between the bond strength values of Maxcem and RelyX ($p > 0.05$). The TAP-RelyX group had the highest bond strength value and the DAP-BisCem group had the lowest bond strength value. The $Ca(OH)_2$ and TAP medication increased the bond strength of the RelyX resin cement when compared with the control group ($p < 0.05$). There was no significant difference among the Maxcem groups in terms of bond strength values ($p > 0.05$). No significant differences were found between all medicaments and the control group in terms of bond strength values of BisCem ($p > 0.05$). The mix failure type was the most frequent type of failure mode in all groups of cements.

Table 1. Push-out bond strength in all test groups.

SARC	Medicaments	Mean (MPa)−std. deviation
RelyX	Control	7.13 ± 2.39^{a}
	TAP	11.08 ± 3.03^{b}
	DAP	6.85 ± 2.42^{a}
	CH	9.49 ± 2.73^{b}
Maxcem	Control	5.96 ± 2.94^{a}
	TAP	7.81 ± 1.81^{a}
	DAP	6.34 ± 1.88^{a}
	CH	8.05 ± 1.36^{a}
BisCem	Control	$4.94 \pm 2.18^{a,b}$
	TAP	$5.19 \pm 3.10^{a,b}$
	DAP	4.26 ± 2.87^{b}
	CH	7.62 ± 2.76^{a}

Note: SARC, self-adhesive resin cement; TAP, triple antibiotic paste; DAP, double antibiotic paste; CH, calcium hydroxide.
Mean values with standard deviations (±SD).
[a,b]Different letters denote statistically significant differences within subgroups ($p < 0.05$).

Many techniques can be used to test the bond strength of luted posts, such as shear (push-out and pull-out test) or tensile force application (microtensile test).[37–39] However, the push-out test has been suggested because of its more regular stress distribution, and also its demonstration of better evaluation results.[40]

Intracanal medicaments are frequently used during root canal therapy for antimicrobial activity.[41] Research suggests that the medication time should be between one and four weeks.[42–44] In the present study, CH, TAP and DAP were removed from root canals after three weeks. However, removal of canal medicaments from the root canal wall is a very difficult, trying and time-consuming procedure.[45] NaOCl and EDTA irrigation combined with various activation techniques are suggested in the literature.[36,44,46,47] Arslan et al. [29] determined that TAP was more effectively removed from artificial grooves by passive ultrasonic irrigation with NaOCl than EDTA. Chou et al. [48] showed that the EndoActivator is an ideal instrument for removing of the steroid antibiotic pastes. Berkhoff et al. [46] showed that TAP was not effectively removed from the root canal systems. In line with this approach, the EDTA and NaOCl combination and sonic agitation for 1 min after each irrigation were used in the present study to achieve more efficient removal of the medicaments.

Since the results from the present study showed that TAP medication increased the bond strength of RelyX, and that BisCem exhibited statistically lower bond strength than RelyX and Maxcem, the null hypothesis was rejected. Other authors have demonstrated that the adhesion of different SARCs to dentin is influenced by CH medications.[9] Antibiotic pastes may also influence the bond strength of the SARC positively or negatively.

To our knowledge, there is no information in the literature about the effects of antibiotic pastes on the adhesion of fibre-post luting agents to root canal walls. Thus, the results from the present study may be compared with research in which the effects of different medicaments on the bond strength of root canal sealers or different root repair materials were evaluated.

For example, Akcay et al. [44] investigated the effects of TAP, DAP and CH medicaments on the bond strength of AH Plus to root dentin. They reported that the bond strength of AH Plus was not adversely affected by the DAP and CH medications, but was increased in the presence of TAP in the middle and apical thirds.[44]

When the materials and methods used in this study were compared with clinical operative procedures, clinical applications were not fully reflected. Therefore, this method was preferred to see directly how medicaments dressing and removal of remnants affect the bond strength of SARC.

In this study, the superior push-out bond strength observed in the TAP-RelyX group compared with other groups could be attributed to the chelating effect of minocycline. Minocycline in TAP binds to calcium ions in the dentin structure, therefore, this may enhance the bonding of the cement to dentin.[46] For the RelyX group, the bond strength of the cement was increased in the TAP and CH medication groups. In contrast, there was no significant difference among the TAP, DAP and CH medicaments, and the control group for Maxcem and BisCem cements. However, the use of medicaments in root canals may change the histochemical composition of dentine, which may alter the push-out test results. That is why further studies are necessary in order to gain better understanding of the physicochemical effects of medicaments on dentine.

In this study, different SARCs, including RelyX, Maxcem and BisCem, were evaluated after different medicaments. Although similar behaviour was expected for all materials, RelyX had higher bond strength values in all medicaments. The high adhesion values obtained with RelyX were likely due to its different setting reactions. According to the manufacturer, RelyX automatically changes its properties from being hydrophilic to being hydrophobic during the setting process. The initial hydrophilic properties provide good adaptation to the tooth surface and a high moisture tolerance, followed by development of hydrophobic properties that ensure the results of low expansion, low solubility and high long-term stability.

Conclusions

The results from this study showed that RelyX and Maxcem had higher bond strength to root canal dentin than BisCem. TAP medication increased the adhesion of RelyX. To the best of our knowledge, this study is the first to demonstrate that the CH and TAP medication increased the bond strength of the RelyX resin cement. The bond strength of Maxcem and BisCem was not negatively affected by the use of intracanal medicament. Thus, further studies may investigate the effect of the medicaments on the push-out bond strength of different root canal materials.

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The authors deny any conflicts of interest related to this study.

Disclosure statement

No potential conflict of interest was reported by the authors.

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