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ORIGINAL ARTICLE

Effect of various intracanal medicaments on the bond strength of self-adhesive resin cement to root canal dentin

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Abstract

Objective: It has been shown that the irrigating solutions and medicament used during root canal treatment may affect the bonding strength. The aim of this study was to evaluate the effect of triple antibiotic paste (TAP), double antibiotic paste (DAP) and calcium hydroxide (CH) on the bond strength to root dentin of self-adhesive resin cement.

Materials and methods: Forty-eight single-rooted human teeth were prepared and randomly divided into one control and three experimental groups (dressing with TAP, DAP or CH). After removal of intracanal dressing, post-spaces were created and fiber posts cemented to the root canal using a self-adhesive resin cement. A push-out test was performed. The data obtained from the push-out test were analyzed using analysis of variance and Bonferroni *post hoc* tests ($p = 0.05$).

Results: TAP decreased the bond strength of self-adhesive resin cement bond strength to root dentin compared to the control group ($p = 0.012$), while CH and DAP did not influence this ($p > 0.05$). The majority of specimens exhibited adhesive failures.

Conclusions: TAP decreased the bond strength of self-adhesive to the root dentin compared to the control group.

Keywords

Calcium hydroxide, double antibiotic paste, minocycline, self-adhesive resin cement, triple antibiotic paste

History

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Introduction

Restoring endodontically treated teeth with fiber reinforced composite posts to retain coronal restoration has become popular. Fiber posts have a modulus of elasticity close to that of dentin.[1] The longevity of the restorations depends on many factors, such as the effectiveness and durability of the bonding between the post, dentin and adhesive resin cement.[2] Effective bonding can contribute to a reduction of stress generated on the root canal walls, thereby strengthening the remaining tooth structure and decreasing the risk of fracture.[3] However, it has been shown that the irrigating solutions and medicament used during root canal treatment may affect the bonding, resulting in reduced bond strength.[4]

Elimination of bacteria and their by-products from the root canal system is one of the goals of root canal therapy. Thus, the combination of the instrumentation and various irrigation solutions and medicaments was suggested.[5] Calcium hydroxide (CH) has been established as the most frequently used medicament because of its antimicrobial efficacy against most bacterial species identified in endodontic infections.[6] Since infections of the root canal system are considered to be polymicrobial, consisting of both aerobic and anaerobic bacteria species, different antibiotic combinations have also been suggested.[7–9] Triple antibiotic paste (TAP) has been found to have good antimicrobial properties and to be biocompatible.[10,11] It consists of ciprofloxacin, metronidazole and minocycline and was developed by Hoshino et al.[12]

Recently, Yassen et al.[13] demonstrated that CH and antibiotic pastes caused degradation or demineralization of radicular dentin, which could negatively affect the adhesion of self-adhesive resin cement to the root canal dentinal walls. The aim of this study was to evaluate the effect of TAP, double antibiotic paste (DAP) and CH on bond strength to root dentin of a self-adhesive resin cement. The null hypothesis tested was that the TAP, DAP and CH would not affect the adhesion between the self-adhesive resin cement and root dentin.

Materials and methods

The sample size for this study was determined as 96 at 91% power and 0.40 effect size ($\alpha = 0.05$). For this purpose, 48 single-rooted, non-carious, human mandibular premolar teeth

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with similar lengths and completed apices, extracted for reason not related to this study, were selected. The presence of a single root canal was verified with buccolingual and mesiodistal radiographs. Caution was paid to make sure that all the root canals had a straight root and similar initial apical file sizes (#15). The teeth were immersed in 0.5% chloramine-T solution for 48 h for disinfection and were stored for up to 1 month in distilled water, being changed daily until use. Soft tissues and calculus were mechanically removed from the surfaces of the roots using a periodontal scaler. Each tooth was decoronated using a diamond disc (Diamond disc superflex 910S/220; North Bel, Italy) operated perpendicularly to its longitudinal axis to obtain a standardized root length of 15 mm.

A #15 K-file (Dentsply, Maillefer, Ballaigues, Switzerland) was moved down in the canal until the file was just visible. The working length was set by deducting 1 mm from this length. The root canals were shaped with ProTaper rotary instruments (Dentsply Maillefer, Ballaigues, Switzerland) up to a size #40 (F4) at working length. The root canals were irrigated with 2 ml of 5% NaOCl (ImidentMedEndosolve-HP, Konya, Turkey) between instrument changes. The apices of the specimens were closed with boxing wax. The teeth were irrigated for 120 s with 5 ml of 17% ethylenediaminetetraacetic acid as a final flush and then irrigated with 5 ml of 5% NaOCl for 120 s, followed by a final rinse with 5 ml of distilled water to remove the smear layer. All the irrigation procedures were performed via a size 27 gauge notched-tip needle (Ultradent, UT) at a distance 1 mm from working length. The needle was then moved backward and forward (flow rate = 0.041 ml/s).

The specimens were dried using paper points (Dentsply Maillefer) and were randomly divided into a control group (without intracanal dressing), and three experimental groups that received an intracanal dressing, with either CH, DAP or TAP.

Preparation of intracanal medicaments

*DAP group (*n = *12)*

Equal portions of metronidazole (Eczacıbası, Istanbul, Turkey) and ciprofloxacin (Biofarma, Istanbul, Turkey) were mixed with distilled water.

*TAP group (*n = *12)*

Equal portions of metronidazole, ciprofloxacin and minocycline (Ratiopharm, Ulm, Germany) were mixed with distilled water (a powder/liquid ratio of 3:1).

*CH group (*n = *12)*

The CH paste in this group was prepared by mixing CH powder (Kalsin; Spot Dis Deposu A.Ş., Izmir, Turkey) and distilled water.

The powder/liquid ratios of the pastes were 3:1. The prepared pastes were placed into the root canals using a size #40 lentulo spiral. The coronal openings of the root canals were sealed with a small cotton pellet and temporary filling material (META Biomed Co. Ltd., Cheongju, Korea). The specimens were stored at 37 °C in 100% humidity for 4 weeks.

After 4 weeks, the intracanal dressing was removed by rinsing with 10 ml of 2.5% NaOCl. Root canal filling was not performed prior to the post-preparation to avoid interference of the filling material in the analysis of adhesion.[14] A 10-mm deep post-space was made using a 1.2-mm size drill (Cytec Carbon; Hahnenkratt GmbH, Königsbach-Stein, Germany). The post-space was rinsed with 5 ml of distilled water and dried with paper points. The self-adhesive resin cement (RelyX U200; 3 M ESPE, Seefeld, Germany) was applied directly into the post-space. Size #1 smooth carbon fiber posts (1.2 mm diameter) (Cytec Carbon; Hahnenkratt GmbH, Königsbach-Stein, Germany) were inserted into the post-space applying a digital pressure. Shortly after, excess cement was removed and light-cured for 40 s before the coronal opening was sealed using composite resin (3M ESPE, Seefeld, Germany) and the specimens stored at 100% humidity, 37 °C for 24 h to completely set.

Next, each specimen was sectioned perpendicular to its long axis using a diamond disc (Arbor, Extec, Enfield, CT) and a precision saw (Isomet 1000; Buehler, Lake Bluff, IL) at low speed under water cooling. Two slices at 1-mm thickness were obtained from the middle third of each root ($n = 24$ for each group).

A push-out test was performed on each specimen with 1 mm diameter cylindrical plugger using an Instron universal test machine (Instron Corp., Canton) at a crosshead speed of 0.5 mm/min. The maximum load at failure was recorded in Newtons (N) and converted to MPa by dividing the load by the bonded area (A). Because the post is conical at only the apical part, and parallel at the middle and coronal parts, the bonded area was calculated using the following formula: $A = 2\pi rh$, where h represents the thickness of the section (mm) and r represents the radius of the post-segment (mm).[14–16]

After the test procedure, each specimen was visually examined under a stereomicroscope at 25× magnification to evaluate failure mode. Three types of failure were classified: adhesive failure (between the cement and root dentin), cohesive fracture (within the dentin, cement layer or post) and mixed (a combination of cohesive and adhesive) (Figure 1).

The Kolmogorov–Smirnov statistical test for normality revealed a normal data distribution ($p = 0.836$). Tests of homogeneity of variance revealed that the variances were homogeneous ($p = 0.321$). Analysis of variance and Bonferroni *post hoc* tests were performed to evaluate the effect of medicament on bond strength ($p = 0.05$). All the statistical analyses were performed using IBM® SPSS® Statistics 20 software (IBM SPSS Inc., Chicago).

Results

Mean bond strength values and SDs after the push-out test are shown in Table 1. Statistical analysis revealed that TAP decreased the bond strength of self-adhesive resin cement to root dentin as compared to the control group ($p = 0.012$). CH and DAP did not influence the bond strength of the self-adhesive resin cement ($p > 0.05$). Adhesive failure between cement and dentin was the most frequent type of failure mode in all the groups except the control group (Table 1).

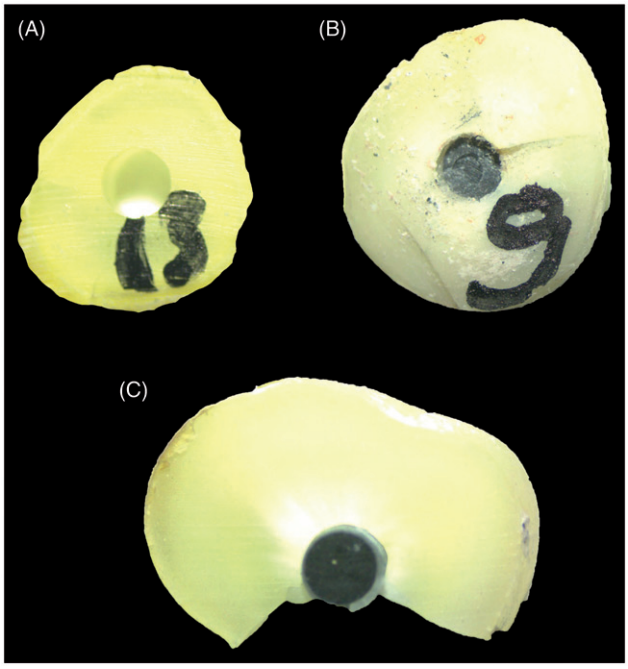

Figure 1. Representative images for the failures. (A) Adhesive failure (between the cement and root dentin), (B) cohesive fracture (within the dentin, cement layer or post) and (C) mixed (a combination of cohesive and adhesive).

Table 1. Mean bond strength ± SD and failure modes of the experimental groups.

		Failure modes (%)		
Group	Bond strength ± SD	Adhesive	Cohesive	Mixed
Control	6.82 ± 3.00a	58.3	33.3	8.3
Calcium hydroxide	5.22 ± 2.78ab	62.5	16.7	28.8
DAP	5.73 ± 2.45ab	45.8	28.8	33.3
TAP	4.25 ± 2.09b	58.3	16.7	25

Different letters shows the statistically significant differences.

Discussion

Antibiotic pastes have been used as intracanal medicament in different clinical scenarios to control endodontic infections.[7,9,17] In a recent study, it was shown that antibiotic pastes caused significant decrease in the microhardness of root dentine.[13] Moreover, Panighi and G'Sell[18] demonstrated that bond strength is strongly correlated to the microhardness of dentin surface. The decrease in microhardness caused by the intracanal medicaments could also affect sealing ability and adhesion. Thus, the purpose of this study was to evaluate the effect of TAP, DAP and CH on the bond strength to root dentin of self-adhesive resin cement.

TAP with minocycline has been found to be superior to CH in killing bacteria inside the biofilms.[19] Although, because of its antibacterial properties, it is advantageous to make use of the minocycline in TAP, the results of this study showed the bond strength of self-adhesive resin cement to root dentin to decrease after application. The minocycline in TAP chelates calcium ions to form insoluble complexes that remain in calcifying tissues, and it could be this chelation that prevented the adhesion of the self-adhesive resin cement. Gerth et al.[20] reported that RelyX Unicem, ancestor of RelyX U200, chemically interacts with calcium ions from hydroxyapatite. The chelation of the calcium ions by acid groups induces this interaction.[20] However, if minocycline was used for the disinfection, the minocycline would chelate the calcium ions, and because minocycline chelates calcium ions and the self-adhesive resin cement does not, the bonding strength would be negatively affected. It seems that the chelation and reduction in the microhardness may explain the decreased bond strength after the application of TAP with minocycline.[13,21] Another possible explanation for the reduced bond strength might be due to incomplete removal of medicament.

In the present study, the application of CH for 4 weeks did not affect the bond strength to root dentin of self-adhesive resin cement as compared to the control group. RelyX U200, recently introduced, was used as the self-adhesive resin cement here. Renovato et al.[14] used RelyX U100, the previous version of RelyX U200. They also investigated the bond strength to root canal dentin of self-adhesive resin cement, focusing on the effects of CH paste, endodontic irrigants and time of application. According to the results of these investigators, the bond strength of groups that received CH paste was similar to that found in the control group. This finding is harmonious with our results.

The analysis of failure modes in the present study revealed that most failures in the fiber post-group occurred between the dentin and the resin cement, which is also in accordance with result from similar study.[22] It is well documented that the luting materials for fiber posts should be self- or dual-cured to overcome the reduced light transmission. Moreover, better polymerization may improve adhesion of the fiber posts to dentinal walls.[23] To ensure that, in the present study, a dual-cure resin cement was used as the luting cement.

A limitation in the present study was that the root canal filling was not performed prior to the post-preparation. This was performed to avoid interference of the filling material in the analysis of adhesion and make easy the direct interpretation of the findings regarding the remaining of the medicaments into the root canal.

In a recent study, Akcay et al.[24] demonstrated that TAP induced crown discoloration, while DAP did not (for the study period of 3 weeks after placement). In the present study, DAP did not influence the bond strength of the self-adhesive resin cement. Thus, DAP seems to have an advantage over TAP. Future studies should thus be conducted to compare the microbial efficiency of these pastes in order to make an overall assessment of the relative merits of these two pastes.

Conclusion

Within the limitation of the present study, TAP decreased the bond strength of self-adhesive to the root dentin compared to the control group.

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Declaration of interest

The authors deny any financial affiliations related to this study or its sponsors.

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