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Original research

The influence of the irrigant QMix on the push-out bond strength of a bioceramic endodontic sealer

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Purpose

The aim of this study was to evaluate the effect of a commercially available irrigant, the Qmix 2 in 1, on the push out bond strength of Endosequence BC which is a bioceramic based root canal sealer.

Material and methods

Sixty extracted maxillary central incisors were prepared with Protaper Next rotary instrument up to X4 (# 40). The specimens were randomly divided into four groups of equal sample size (n=15), according to the final irrigation regimen as follows: Group 1: 2.5% sodium hypochloride (NaOCl) (control), Group 2: 17% ethylenediaminetetraacetic acid (EDTA), Group 3: 2% Chlorhexidine (CHX), Group 4: QMix 2 in 1. After rinsing, teeth were obturated using gutta-percha with Endosequence BC sealer. Slices were obtained from coronal, middle, and an apical section of the root canal. Push-out test was performed to evaluate the bond strength between the root canal dentin and the sealer. Data was statistically analyzed.

Results

The push-out bond strength of the root canal sealer was significantly affected by the type of irrigation solution. Highest bond strengths were found in canals irrigated with Qmix solution, and these results were regardless of anatomical section of the root canal ($p < 0.05$).

Conclusion

Final irrigation of the root canals with QMix had a positive effect on the bond strength of Endosequence BC sealer throughout the root canal.

Keywords: *Endosequence BC sealer; irrigant; push-out test; Qmix; endodontics*

Introduction

The main aim of endodontic treatment is to eliminate micro-organisms from the root canal system and inhibit reinfection (1). Mechanical instrumentation is definitely one of the important factors in reducing the bacterial load of the infected root canals (1), although it is not completely effective in removing all bacteria and debris (1). Ability of instrumentation alone to debride and clean the canal is limited (2-5). Peters *et al.* (2, 3) reported that large areas of the root canal walls could remain untouched, regardless of the instrumentation technique. Accurate instrumentation and debridement of root canals is often very complicated and difficult because of their anatomical characteristics. Most of them demonstrate oval morphology in shape and include the lateral canals, isthmuses, and deltas (2, 3). Rödig *et al.* (4) showed that debridement with the nickel-titanium (Ni-Ti) rotary instruments of buccal and lingual extensions of oval canals may still be inadequate. Similarly, Wu and Wesselink (5) reported that uninstrumented areas may be left in many oval canals after the instrumentation. Therefore,

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irrigation of root canals is the only way left to eliminate microorganisms and debris from the root canal walls, which could not be reached by mechanical instrumentation.

Sodium hypochlorite (NaOCl) solutions in concentrations ranging from 0.5% to 6.15% have been used as endodontic irrigants for more than 70 years, and they are still the most commonly used solutions for this purpose (5). Sodium hypochlorite solution has bactericidal and virucidal properties and it dissolves necrotic tissue (6). Moreover, NaOCl has a low viscosity and long shelf life (6). On the other hand, this solution may be toxic and cannot break up inorganic contents of the smear layer (7). Because of this, NaOCI has been used with chelating agents like ethylenediaminetetraacetic acid (EDTA) in 15-17% concentrations for smear layer removal. Combined used of these irrigants represents the current optimal irrigation protocol. However, NaOCI and EDTA should not be combined *in situ*, because EDTA strongly reduces free chlorine in NaOCI solutions, mostly rendering them ineffective (8, 9). Furthermore, it has been shown that using NaOCI as a final irrigant after the use of EDTA may compromise the structural integrity of the dentin (8, 9). Chlorhexidine (CHX) solution in 2% concentration is also a widely used root canal irrigation solution. It has long term antimicrobial effect, comparatively low toxicity (7). However, when CHX comes in contact with residual NaOCI, subsequent chemical reaction produces para-chloroaniline precipitate which is potentially toxic (10). Thus, it requires to remove any remaining NaOCI solution from the root canal with saline, alcohol or distilled water prior to CHX application (10).

To overcome these problems in the irrigation of the root canals, a new irrigation solution, QMix 2in1 (Dentsply Tulsa Dental, Tulsa, OK), has been introduced to market for smear layer removal with antimicrobial efficiency. It comprises of EDTA, CHX, a detergent and deionized water. It is designed as a final irrigant to replace 17% EDTA final wash protocol, and is used for 60-90 seconds (11). QMix is a ready-to-use clear solution, and requires no chair-side mixing. It has been shown that QMix 2in1 is effective in both removing the smear layer and killing bacteria such as *Enterococcus faecalis* in one application (11). Elnaghy (12) reported that QMix 2 in1 could remove the smear layer more effectively than 17% EDTA and 17% EDTA/2% CHX based on the completely opened dentinal tubules. Eliot *et al.* (13) have also stated that QMix removed more smear layer than EDTA. Furthermore, QMix eliminates some disadvantages of both EDTA and CHX. It does not interact with residual NaOCI if used for the purpose of final irrigation (14).

Using gutta-percha with various types of sealers is the standard technique in endodontic obturations. Tricalcium silicate based Endosequence BC Sealer (Pulpdent, Watertown, Massachusetts USA) has recently been used to treat root canals. It is an aluminum-free material comprised of calcium, calcium phosphate, zirconium oxide and calcium hydroxide that requires the existence of water to harden. It shows alkaline pH, antibacterial activity, radio-opacity and biocompatibility (15).

The use of irrigants before the obturation of root canals is very important to dissolve organic and inorganic contents of the smear layer, to clean the dentin walls and enhance the bonding of root canal sealers. The data regarding the effects of QMix irrigation solution on the bond strength of root canal sealers is limited. Therefore, the aim of the present study was to assesment the effect of QMix irrigant on the push out bond strength of a bioceramic endodontic sealer. The main null hypothesis tested in the present study is that the push-out bond strength of Endosequence BC sealer in root canals irrigated with Qmix is not different from those irrigated with NaOCL, EDTA and CHX.

Materials and methods

Specimen selection

This *in vitro* study was conducted on 60 maxillary central incisors extracted within 6 months prior to the experiments and stored in 0.1% thymol solution at 4°C. The inclusion criteria were straight canals and completely formed apices. The exclusion criteria were teeth with root caries, cracks, resorption, incomplete apices, or those with root length less than 15 mm. This study was confirmed by the Research Ethics Committee of Medipol University (project no: 324).

Specimen preparation

The specimens were stored in 1% Chloramine T solution (Ricca Chemical Company, Arlington, TX) for 48 hours for disinfection. Then, the external root surfaces were scaled with ultrasonic instruments, and rinsed with distilled water for the elimination of remnants from the root surface. The crowns were sectioned transversally at the cementoenamel junction. and the root length was set to 15 mm, and later access cavity was established, the working length was detectioned by a direct method of withdrawing 1 mm from the real root length. Root canals shaping were done with Protaper Next (Dentsply / Maillefer, Ballaigues, Switzerland) up to X4 (#40) master apical file size. During the shaping, the root canal was irrigated by 2 mL 2.5% NaOCl (ImidentMed, Konya, Turkey) solution after preparation with each file. The roots were then randomly divided into four groups (n=15) according to the final irrigation ptotocol as follows: Group 1: 5 mL of 2.5% NaOCl for 60 seconds (control)**,** Group 2: 5 mL of 17% EDTA solution (Pulpdent, Watertown, Massachusetts USA) for 60 seconds, Group 3: 5 mL of 2% CHX (Consepsis, Ultradent, South Jordan, UT) for 60 seconds (washed with distilled water before CHX application)**,** Group 4: 5mL QMix 2in1 (Dentsply Tulsa Dental, Tulsa, OK) for 60 second.

Root canals irrigated with a 30-g side-perforated irrigation probe (Canal Clean, Biodent Co. Ltd, South Korea) and a syringe. Final rinsing was done for one minute in each canal. At the procedure of irrigation, the needle was used with up and down movements in the canal to within 1-2 mm of the working length. Subsequent to the procedures, all the canals were dried using paper points and obturated with Endosequence BC sealer (Brasseler USA, Savannah, GA) using the single cone technique with matching taper X4 gutta-percha cones (Dentsply Maillefer, Ballaigues, Switzerland) to achieve standard samples for push-out test. After root obturation, the coronal accesses of the root canals were sealed with temporary filling material. Teeth were stored at 37°C and 100% relative humidity for seven days to allow the sealer to set.

Push-out bond strength

Each samples was horizontally cut with a low-speed diamond. saw (Isomet, Buehler, Lake Bluff, IL, USA) under cold water irrigation. Three slices in 2±0.1 mm thickness were obtained from the coronal, middle, and apical sections of the roots. Apical and coronal aspects of each slice were examined under a stereomicroscope (Imaging Systems, Leica Ltd., Cambridge, England) to measure the diameter of each hole.

Push-out bonding strength was calculated with a universal testing machine (TSTM02500, Elista Inc., Konya, Turkey) at a crosshead speed of 1 mm/min. As for the tapered design of the root canal, three different sizes of cylindrical pins were used for the push-out test. The diameter. of the cylindrical pins was 1.2 mm for the coronal slices, 1.0 mm for the middle slices, and 0.8 mm for the apical slices to make sure that the strength was implemented as adequately as possible to the adhesion area during the loading phase. The highest load implemented to the obturation material before debonding was recorded in Newton (N). The bond strength was calculated in Mega Pascals (MPa) by dividing the load (N) by the adhesion area of root filling (A) (mm^2), with the equation: Mpa = F/A. The parameter A was calculated with this equation: $A = \pi (R + r) \times g$, where R is the coronal radius, r is the apical radius, and g is the height relative to the tapered inverted cone (mm). The parameter g was calculated with this equation: $g^2 = (R - r)^2 + (2.0)^2$.

Statistical analysis

Statistical Package for Social Sciences SPSS version 21.0 (IBM-SPSS Inc, Armonk, NY, USA) software was used for statistical analysis. Data was first examined by use of the Shapiro-Wilk test to verify the assumption of normality and with Levene's test to check for variance equality. As the data was found to be normally distributed, one-way analysis of variance (ANOVA) test for multiple groups and Tukey HSD test for pairwise comparisons were performed. Confidence limit was regulate to 95% and p values less than 0.05 were planned as statistically important.

Results

The effects of the type of irrigant on the push-out bond strength of the root canal sealer are summarized in Table 1.

Table 1. *Mean and standard deviations (SD) of push-out bond strength values of study groups in Megapascal*

	n	Mean±SD	Minimum	Maximum
NaOCl	45	1.18±0.59 A	0.23	2.36
CHX	45	2±0.56 B	0.58	2.95
EDTA	45	2.51±0.42 C	1.76	3.45
QMix	45	3.49±0.61 D	2.45	4.75

CHX: chlorhexidine; EDTA: ethylenediamine tetra acetic acid; NaOCl: sodium hypochlorite
Different uppercase letters in columns show statistically significant differences at $p<0.05$ level

There was a significant difference between the push out bond strengths of Endosequence BC sealer with respect to type the irrigation solution ($p<0.05$). Endosequence BC sealer showed the highest bond strength values when QMix 2in1 was used as the final irrigant ($p<0.05$). On the other hand, Endosequence BC sealer showed the lowest bond strength values when NaOCl was used as the final irrigation solution ($p<0.05$). These results were regardless of anatomical section of the root canal ($p<0.05$).

Discussion

Adhesion capability is a crucial factor for root canal sealers. An ideal endodontic sealer must bond to both the gutta percha and root dentin surface and must seal the root canal space (16). The effects of different irrigation solutions on the bond strength of resin based sealers to dentin have earlier been investigated (15-19). However, there is no comparative data regarding the effects of Qmix and other irrigants on the push out bond strength of a bioceramic based endodontic sealer. In the present study, we used Endosequence BC as a root canal sealer to test the effects of different irrigation solutions on its bond strength to the dentin surfaces.

The smear layer may negatively affect the bond strength of root canal sealers by acting as a barrier. As it also contains organic and inorganic contents, it should be effectively removed by different irrigation solutions (16). Studies have shown that, removing the smear layer makes it easier for the canal sealer to penetrate dentin tubules (20-23). EDTA and NaOCl solutions are commonly used to remove the smear layer from the root canals (24). Because of its residual antimicrobial activity, CHX has been proposed as a supplemental final irrigation procedure after smear layer removal (25). However, the concomitant use of CHX and NaOCl leads to color changes and formation of a possibly toxic, insoluble precipitate which reduces the sealing ability of the root canal filling procedure. Also, this precipitate involves a substantial amount of parachloroaniline, which has been shown to be carcinogenic and toxic (14, 24, 25). This substance acts as a chemical smear layer by coating the dentin surface and by changing permeability of dentin surface (26). Moreover, the mixture of CHX and EDTA was found to form a white precipitate which has a chemical structure of salt. This precipitate may also cover the dentin surface and alter dentin permeability. The chemical pattern of QMix prevents this, when CHX is combined with EDTA or NaOCl.

Previous research concerning the smear layer elimination efficacy of EDTA and Qmix revealed contradictional results (11, 12, 18, 27-29). Some studies reported that QMix could eliminate the smear layer as effectively as 17% EDTA (27-29), while others concluded that QMix was better than 17% EDTA (12, 13). QMix solution is composed of EDTA, CHX and a detergent. It not only penetrates and removes the smear layer in the dentin surface but also kills bacteria within the tubules. Tuncer (18) reported that the percentage of bond strength of sealer was importantly greater in the EDTA + CHX and QMix groups than the NaOCl group. On the other hand, author stated that there was no difference between the efficiency of QMix and EDTA + CHX irrigation for smear layer elimination. Shokouhinejad *et al.*(30) showed that the existence of smear layer did not substantially affect the bond strength of obturation materials. In the present study, Endosequence BC indicated the highest bond strength in root canals irrigated with Qmix. This may be the result of more efficient elimination of the smear layer by the QMix when used as a final irrigant.

Different irrigation solutions may alter the permeability and solubility of the dentin surface and therefore influence the adhesion of root canal sealers to dentin surfaces (22). Adhesion process mainly depends on the wettability of the rigid surface which is provided by the internal dentin wetness as a result of water in dentinal tubules (31). Ballal *et al.* (24) indicated that the wettability of the root canal dentin which is filled with AH Plus sealer is higher in canals treated with Qmix compared to those flushed with EDTA, when both solutions are used as final irrigants. This may be owing to the combined reaction of CHX and the detergent existence in QMix. In addition, Uzunoglu *et al.*(32) showed that bond strength of AH Plus sealer to root canal dentin is improved with QMix. However, Aranda Garcia *et al. (27)* stated that the surfactant compound in Qmix did not increase the bond strength of AH Plus compared to 17% EDTA. Carvalho *et al.*(33) indicated that EDTA did not influence the push-out bond strength of MTA Fillapex and AH Plus. In the present study, various irrigants affected the bond strength of Endosequence BC to the root canal wall differently. Endosequence BC showed higher bond strength after irrigation with QMix than with EDTA and CHX.

Conclusion

Within the limitations of this *in vitro* study, our findings suggest that using QMix may lead to superior retention of Endosequence BC sealer when compared to EDTA and CHX. From clinical perspective, Qmix solution can be used for removing the smear layer and may be considered as an alternative to using EDTA following NaOCl as final irrigant.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Medipol University (project no: 324, date: 15.09.2017).

Informed Consent: This study was performed *in vitro* by exploiting exracted teeth. Therefore written and verbal informed consent was not obtained.

Peer-review: Externally peer-reviewed.

Author Contributions: MG, GPS, EE and ÖYÖ designed the study. MG generated the data. MG and GPS gathered the data. MG, EE and ÖYÖ analyzed the data. GPS wrote the majority of the original draft. MG and GPS participated in writing the paper. All authors approved the final version of the paper.

Conflict of Interest: The authors have no conflicts of interest to declare.

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Türkçe öz: *Qmix irriganının Bioseramik esaslı kök kanal patının dentine bağlanma dayanımı üzerindeki etkisi. Amaç: Bu çalışmanın amacı Qmix irriganının bioseramik esaslı kök kanal patı Endosequence BC'nin dentine bağlanma dayanımı üzerine etkisinin değerlendirilmesidir. Gereç ve Yöntem: 60 adet çekilmiş üst santral diş Protaper Next rotary enstrüman ile X4 (40#)'e kadar şekillendirildi. Numuneler rastgele eşit sayıda olacak şekilde, final irrigasyon yöntemine göre 4 gruba ayrıldı (n:15); Grup1:%2,5 sodyum hipoklorit (NaOCl) (kontrol), Grup2: %17 EDTA, Grup3: %2 klorheksidin (CHX), Grup4: QMix 2 in 1. İrrigasyondan sonra dişler Endosequence BC kanal patı ile güta-perka kullanılarak dolduruldu. Kök kanalının apikal, orta ve koronal üçte birlik kısımlarından kesitler alındı. Push-out testi ile kanal patı ve kök kanal dentini arasındaki bağlanma dayanımı ölçüldü. Datalar istatistiksel olarak analiz edildi. Sonuç: Kök kanal patının dentine bağlanmasını irrigasyon solüsyonunun tipi önemli ölçüde etkilemiştir. Qmix solüsyonu ile en yüksek bağlanma dayanımı oluşurken bu sonuçlar kök kanalının anatomik bölümlerine bakılmaksızın elde edilmiştir. Anahtar kelimeler: Endosequence BC kanal patı; irrigan; push-out test; Qmix; endodonti*

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