Effect of previous irrigation with chlorhexidine on the push-out bond strength of a calcium silicate–based material

Carolina Oliveira de Lima, DDS, MSc ■ Hugo Gonçalves Dutra, DDS ■ Thais Mageste Duque, DDS, PhD
Celso Neiva Campos, DDS, PhD ■ Vasudev Ballal, DDS, PhD ■ Renata Antoun Simão, DDS, PhD
Maíra do Prado, DDS, PhD

This study evaluated the effect of previous irrigation with chlorhexidine (CHX) on the bond strength of a calcium silicate–based material, Biodentine, when used for furcal repair. Furcal perforations were produced in 30 extracted mandibular molars. Teeth were divided into 3 groups according to the irrigant used: distilled water (DW), CHX followed by DW (CHX), and CHX followed by ethylenediaminetetraacetic acid (EDTA) and DW (CHX/EDTA). Biodentine was used to repair the perforations. A push-out bond strength test was performed after 7 days, and data were statistically analyzed using Kruskal-Wallis and Dunn tests ($P < 0.05$). The CHX/EDTA group showed significantly lower values than the DW and CHX groups ($P < 0.05$). The failure mode of the DW group was mainly mixed, while that of the CHX group was cohesive. The CHX/EDTA group exhibited adhesive and mixed failures. Irrigation with CHX prior to furcation repair did not result in a statistically significant difference, compared to the use of DW, in the push-out bond strength of Biodentine.

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A furcation perforation is an opening in a tooth's furcation at the periodontal ligament. It is characterized as a complication that may occur during endodontic treatment or space preparation.[1] The perforation must be repaired as soon as possible to avoid microbial contamination and consequent development of endodontic-periodontal lesions.[2,3]

Various materials are indicated for the repair of furcation perforations, including amalgam, Cavit (3M ESPE), composite resin, glass ionomer cement, calcium hydroxide, Super EBA (Keystone Industries), and mineral trioxide aggregate (MTA).[1,4,5] MTA has been used extensively for furcation repair due to its high sealing capacity, excellent biocompatibility, and ability to set in the presence of blood.[6,7] However, the negative characteristics of this material include a long setting time and difficulty in handling.[8,9]

New materials composed of calcium silicate have been developed with the objective of lessening the deficiencies exhibited by MTA.[10] Biodentine (Septodont) is composed of tricalcium silicate, dicalcium silicate, calcium carbonate, iron oxide, zirconium oxide, and calcium chloride; calcium chloride is used as an accelerator to reduce the setting time of this material.[11] Biodentine has been suggested as a replacement material for dentin—similar to MTA—to be used as a regenerative material in endodontic procedures for furcation perforation repair, retrograde obturation, and pulp revascularization.[1,12]

The materials used in furcation repairs should allow for good adaptation with dentin and should not fracture or dislocate under occlusal mechanical force or during the condensation of regenerative materials.[13,14] A possible cause for the dislocation of these materials is the loss of seal between material and dentin over time, which results from the degradation of collagenous fibers.[15] This process is attributed to an endogenous proteolytic mechanism that involves the activity of metalloproteinases (MMPs) found in root dentin.[16,17]

Chlorhexidine digluconate (CHX) has been proposed as an irrigant in endodontic treatment due to its antimicrobial activity and ability to increase energy on the dentin surface and because it does not affect the adhesive strength between the restorative material and dentin.[18,19] Moreover, CHX has beneficial effects on the preservation of adhesion between the restorative material and dentin, inhibiting the activity of MMPs on dentin.[20,21]

Therefore, the objective of the present study was to evaluate the effect of irrigation with CHX prior to furcation repair on the bond strength between the bioactive material Biodentine and dentin.

Materials and methods

The study was approved by the Ethics in Research Committee at Federal University of Juiz de Fora, Juiz de Fora, Brazil (1.840.821). A total of 30 extracted permanent human molars were used. The teeth were stored in a solution of sodium azide 0.2% (MilliporeSigma) at 4°C until use.

Specimen preparation

Crowns were removed at the cementoenamel junction with a diamond disc (Horico Dental) under water cooling. Roots were standardized to measure 6 mm from the lower region of the furcation to the end of the root. The apical 3 mm of the root was embedded in epoxy resin, leaving 3 mm of the furcation area protruding from the epoxy resin.

A furcation perforation was produced in each tooth by a cylindrical bur (1.6 mm) that was positioned perpendicular to the furcation and parallel to the long axis of the tooth. A collagen matrix (Hemospon, Technew) was later inserted below the perforation, with the aid of a condenser (Odous De Deus), to serve as a shield for irrigation and placement of the calcium silicate–based repair material.

After the collagen matrix was inserted, specimens were divided into 3 groups (n = 10) according to the irrigant used (Table 1): distilled water (group DW), 2% CHX followed by DW (group CHX), or 2% CHX followed by 17% ethylenediaminetetraacetic acid (EDTA) and DW (group CHX/EDTA). The irrigation procedure was performed with a 27-gauge needle and a 5-mL syringe (Vista Dental).

After the assigned irrigation protocol was completed, Biodentine was applied according to the manufacturer's recommendations. Five drops of the liquid were placed in the powder-containing capsule and then vibrated for 30 seconds at 4000 rpm. Once the material presented a consistency of "glass putty," it was inserted in the perforations with the aid of the condenser. Specimens were then wrapped in wet gauze and stored for 7 days at 37°C with 100% humidity.

Push-out bond strength test

Bond strength was assessed through the push-out bond strength test using a universal testing machine (Instron Brasil). The equipment operated at a speed of 0.5 mm/min with a cylindrical apparatus measuring 1.2 mm in diameter and 20.0 mm in length and a load of 200 kgf per load cell. The greatest force intensity before dislodgment was recorded in newtons. To express the bond strength in megapascals, the load value was divided by the area (square millimeters) of the bonded interface, which was calculated with the formula $A = 2\pi rh$, where π is 3.14, r is 0.75 mm (the perforation was standardized with a diameter of 1.50 mm), and h is the height of perforation.

All fractured specimens were observed under a stereoscope (SMZ800, Nikon Instruments) at 10× magnification to determine the failure mode. This failure mode was classified into 3 types: adhesive (failure in the dentin-material interface); cohesive (failure within the material); and mixed (adhesive and cohesive). The assessment was performed by a single trained evaluator.

Table 1. Irrigants evaluated in this study.

Group	Initial irrigation (3 mL)	Removal of smear layer (1 mL)	Final irrigation (1 mL)
Control	DW	DW	DW
CHX	CHX 2%	DW	DW
CHX/EDTA	CHX 2%	EDTA 17%	DW

Abbreviations: CHX, chlorhexidine; DW, distilled water; EDTA, ethylenediaminetetraacetic acid.

Statistical analysis

The descriptive analysis of data and statistical analyses were performed using SPSS software (version 15.0, IBM). The Kolmogorov-Smirnov test was used to assess the normality of the sample. Bond strength results were statistically analyzed using the Kruskal-Wallis test and Dunn test. The level of statistical significance was 5% ($P < 0.05$).

Results

Table 2 shows the bond strength values of all the groups and the failure mode associated with each. The DW and CHX groups presented statistically similar bond strength values ($P = 0.49$). The CHX/EDTA group presented the lowest values, and the mean was significantly different from groups DW ($P = 0.004$) and CHX ($P = 0.005$).

The DW group presented a mostly (70%) mixed fracture pattern, while the CHX group presented a mostly (80%) cohesive fracture pattern, and the CHX/EDTA group presented both adhesive (~50%) and mixed (~40%) patterns.

Discussion

After repair of furcation perforations, the success of endodontic therapy depends on the thorough cleaning and shaping of the root canal system, adequate coronal restoration, and the resistance of the repair material to fracture or dislocation during condensation of the sealing materials as well as in the face of occlusal mechanical forces.[1] Thus, the bond strength of the material used in furcation repair is an important factor. The push-out test has been widely used to assess bond strength because it is practical, reliable, and efficient.[13,22-24]

Irrigants such as 2% CHX and sodium hypochlorite (NaOCl) are recommended during the chemomechanical preparation of the root canal system.[18] Moreover, the use of acids and chelating agents is also recommended to remove the smear layer formed during preparation.[25] Several studies have evaluated the effect of different irrigants used during chemomechanical preparation on the topography and bond strength of materials for furcation repairs.[1,3,4,26] However, the effect of irrigants prior to repair has rarely been addressed in the literature.

Pace et al carried out a 5-year follow-up on a series of clinical cases in which irrigations with 5% NaOCl, 17% EDTA, and DW were performed prior to the insertion of repair material in furcations, treatment that resulted in clinical and radiographic success.[27] However, previous studies have shown

Table 2. Bond strength values (push-out test) of Biodentine to dentin and fracture patterns of specimens.

	Bond strength (MPa)			Failure mode (%)		
Group	Mean (SD)	Min	Max	Adhesive	Cohesive	Mixed
DW	3.35 (1.43)^{A}	0.95	5.55	10	20	70
CHX	4.09 (2.81)^{A}	0.59	8.52	0	80	20
CHX/EDTA	1.35 (1.32)^{B}	0.12	3.49	50	10	40

Abbreviations: CHX, chlorhexidine; DW, distilled water; EDTA, ethylenediaminetetraacetic acid; Max, maximum; Min, minimum.
Different uppercase superscript letters indicate statistically significant differences ($P < 0.05$; Dunn test).

sodium hypochlorite to have high toxicity when in contact with periradicular tissues.[28,29] Moreover, Alsubait evaluated the effect of irrigation with 2.5% NaOCl on bond strength after inserting furcation repair materials and observed that NaOCl decreased the bond strengths of MTA and Biodentine.[30]

CHX offers antimicrobial activity and the ability to increase energy on the dentin surface; it also plays a role in preserving the adhesion between restorative material and dentin by inhibiting the activity of MMPs. Thus, in view of these advantages and considering the negative effects of NaOCl, the present study was undertaken as the first investigation of the effects on the bond strength between Biodentine and dentin when irrigation with CHX is performed prior to furcation repair.

In the present study, irrigation with CHX prior to furcation repair did not result in a statistically significant difference in dentin–repair material bond strength compared to the use of DW ($P = 0.49$). Mixed fractures predominated in the DW group (70%), while cohesive fractures were mainly observed in the CHX group (80%). These findings demonstrate that, although there was no statistically significant difference in bond strengths between them, the CHX group presented a more favorable fracture mode than the DW group.

The favorable bond strength between the bioactive repair material and dentin, which was demonstrated by the predominantly cohesive failures in the CHX group, can be explained by the various positive aspects of this irrigant. These aspects include the ability of this substance to increase surface energy on the dentin, the fact that CHX does not affect the adhesive strength between restorative material and dentin, and the role CHX plays in the preservation of adhesion between the restorative material and dentin by inhibiting the activity of MMPs on dentin.[18-21]

In the present study, irrigation with CHX and 17% EDTA (group CHX/EDTA) decreased the bond strength between the calcium silicate–based material and dentin. This result may be associated with the demineralizing effect of EDTA on calcium-based materials.[3] Moreover, a chemical smear layer may have formed on the dentin surface.[25] The CHX/EDTA group presented predominantly adhesive (~50%) and mixed (~40%) failures, confirming the negative action of irrigation with CHX/EDTA prior to placement of Biodentine in the perforation.

Thus, the use of CHX as an irrigant prior to sealing of perforations did not result in a statistically significant difference in bond strength between Biodentine and dentin when compared to the use of distilled water, but CHX/EDTA showed the worst bond strength when compared to the other protocols for prior irrigation. However, the cohesive failure mode observed in the CHX group was the most favorable among all groups.

Conclusion

Irrigation with CHX prior to furcation repair did not result in a statistically significant difference in bond strength between Biodentine and dentin when compared to the use of DW.

Author information

Drs de Lima and Dutra are in private practice, Rio de Janeiro, Brazil. Dr Duque is a professor, Department of Dentistry, Federal University of Santa Catarina, Santa Catarina, Brazil. Dr Campos is a professor, Department of Dental Clinic, Federal University of Juiz de Fora, Juiz de Fora, Brazil. Dr Ballal is a professor, Department of Conservative Dentistry & Endodontics, Manipal College of Dental Sciences, Manipal Academy of Higher Education, Manipal, India. Dr Simão is a professor, and Dr do Prado is a researcher, Department of Metallurgical and Materials Engineering, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil.

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