Effect of Root Dentin Conditioning on the Pushout Bond Strength of Biodentine

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Abstract

Introduction: Sodium hypochlorite (NaOCl) is the main irrigant to clean root canals. Decalcifying agents are advocated as additional means to condition the root dentin. The aim of this study was to evaluate the effect of alternating (EDTA) or continuous 1-hydroxyethane 1,1-diphosphonic (HEDP) chelation in conjunction with NaOCl irrigation on the pushout bond strength of Biodentine (Septodont, Saint Maur des Fosses, France). **Methods:** Single root canals of 50 extracted, mature human teeth were divided into 5 groups (n = 10) and enlarged using rotary instruments. Canals were irrigated with 5 mL irrigant after each instrument and then with 5 mL after mechanical preparation as follows: 2.5% NaOCl during and then 2.5% NaOCl, 17% EDTA, or 17% EDTA followed by 2.5% NaOCl after preparation. Continuous chelation with 2.5% NaOCl/9% Dual Rinse HEDP (Medcem GmbH, Weinfelden, Switzerland) during and after preparation. The control group was irrigated with water during and after preparation. Canals were then filled with Biodentine. A horizontal section of 1.5-mm thickness was taken from the middle root third, and a pushout bond test was performed. Data were statistically analyzed using 1-way analysis of variance/Tukey honest significant different test. **Results:** The pushout bond strength of Biodentine was significantly higher when the root canal was irrigated with 2.5% NaOCl/9% Dual Rinse HEDP (19.6 ± 2.3 MPa) than with NaOCl alone (15.5 ± 1.5 MPa) or the NaOCl/EDTA sequences (15.7 ± 2.2 MPa and 16.9 ± 2.9 MPa) ($P < .05$), which did not differ among each other ($P > .05$). The lowest pushout bond strength values were found with water irrigation (11.5 ± 0.5 MPa) ($P < .05$ to all other groups). **Conclusions:** Irrigation with 2.5% NaOCl/9% Dual Rinse HEDP significantly improved the pushout bond strength of Biodentine to the root canal dentin. *(J Endod 2018;■:1–5)*

Key Words

Biodentine, dual rinse HEDP, EDTA, pushout bond strength, smear layer, sodium hypochlorite

Significance

Irrigation with 2.5% NaOCl/9% Dual Rinse HEDP can improve the pushout bond strength of Biodentine to the root canal dentin.

The essential part for endodontic success is proper cleaning of the root canal system (1). Studies have shown that large areas of root canal walls remain untouched by hand and rotary instruments during canal preparation. This shows the importance of cleaning and disinfecting the root canal system using chemical means. To this end, the combined use of 2 or more irrigating solutions in a specific sequence can be used to predictably achieve the goals of safe and optimal irrigation.

During mechanical preparation, a smear layer is produced in the root canal system on instrumented canal walls, whereas the noninstrumented area can be covered by dentin mud and debris (2). Studies have shown that these entities can impede sealer penetration into the dentinal tubules, thereby compromising the seal of obturating materials (3). In some cases, the smear layer and debris can be infected, thereby protecting the microorganisms within the dentinal tubules and in isthmus areas (4). Furthermore, the infiltration of root canal irrigants and intracanal medicaments into the dentinal tubules can be impeded (5), and microleakage can occur.

Sodium hypochlorite (NaOCl) is the most widely used irrigant in endodontics because of its potential to dissolve organic tissue as well as its antimicrobial properties (6). In addition to NaOCl, the following chemical agents that aid in the elimination of the smear layer and debris have been proposed and used in clinics: EDTA and its various formulations, tetracycline, a mixture of a tetracycline isomer, an acid and a detergent, organic acids such as maleic and citric acid, tannic acid, and 20% polyacrylic acid. EDTA is a polyaminocarboxylic acid that is water soluble in a neutral or alkaline pH. It is used in endodontics because of its chelating property whereby it interacts with calcium ions present in dentin to form soluble chelates of calcium. It is the most widely used chelating agent in endodontics (7). However, it has various drawbacks including reduced efficacy in the elimination of the smear layer in the apical third (8), a reduction in dentin microhardness (9), and cytotoxicity (10). Furthermore, it also reduces the bond strength of resin cements (11), brings about a reduction in active chlorine when combined with NaOCl (12), and forms a precipitate in combination with chlorhexidine (13).

Etidronic acid (also known as 1-hydroxyethane 1,1-diphosphonic [HEDP]) is a biocompatible chelator that can be used in conjunction with NaOCl. It is a ''soft'' chelator that is less aggressive on dentin than EDTA (14). Studies have shown that it has a weak chelating capacity when used alone (15). This property can be used to the advantage of using NaOCl and HEDP as a single irrigant during and after root canal

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preparation. It was shown that a freshly mixed irrigant, containing HEDP and NaOCl, dissolves the smear layer. The combination is also shown to reduce the accumulation of hard tissue debris in the isthmus area (16). Dual Rinse (9% HEDP) (Medcem GmbH, Weinfelden, Switzerland) is a medical device (product approved for use in the root canal) based on this chemistry. It comes in a capsule containing 0.9 g etidronate powder, which should be mixed immediately with 10 mL of the NaOCl solution of choice directly before treatment. This solution remains useful for 1 hour with all the desired properties of NaOCl remaining intact (17). Additionally, this combined solution of HEDP and NaOCl inhibits smear layer formation during instrumentation as well as conditions the root canal wall for subsequent obturation (7, 18). A mixture of HEDP and NaOCl can be used not only during root canal instrumentation but also as a final irrigant.

Biodentine (Septodont, Saint Maur des Fosses, France) is a tricalcium silicate developed by Septodont's research group as a new range of dental material that exhibits superior mechanical properties besides biocompatibility and bioactivity. It is used as a dentin replacement material whenever original dentin is damaged. Biodentine has a relatively short setting time of around 12 minutes when compared with MTA, which takes 3 to 4 hours to set (19). Biodentine is comprised of a highly distilled tricalcium silicate powder that is prepared synthetically in the laboratory and not from a clinker. Biodentine is known to show excellent sealing ability with the aid of mineral tags into the dentin tubules with excellent microleakage resistance, promoted by the lack of shrinkage because of the resin-free formula (20). Considering the clinical applications for tricalcium silicate cements, the marginal adaptation as well as the bond strength of these materials with dentin plays a significant role in clinical practice.

The pushout bond strength test evaluates the bond strength of a restorative material to root canal dentin. It is a practical and reliable method to evaluate the adaptation of a material to its surrounding root dentin (21). Various studies have tested the pushout bond strength of tricalcium silicate cements to root dentin after irrigation with various regimens (22). Up to now, the effect of Dual Rinse on the bond strength of Biodentine to root canal dentin has not been sufficiently investigated. Hence, the aim of this study was to evaluate the effect of 17% EDTA, 9% Dual Rinse HEDP, and 2.5% NaOCl when used with different irrigation regimens on the pushout bond strength of Biodentine to the root canal dentin.

The null hypothesis tested was that there is no significant difference in the pushout bond strength of Biodentine to root canal dentin irrigated with 2.5% NaOCl, 2.5% NaOCl followed by 17% EDTA with or without a final rinse of 2.5% NaOCl, 2.5% NaOCl/9% Dual Rinse HEDP, and distilled water.

Materials and Methods

Sample Size Estimation

The number of samples included in this study was based on the pushout bond strength of mineral trioxide aggregate to root canal dentin treated with different irrigants (21). Based on this, the sample size was estimated at a 95% confidence interval and with the power of 80%, which resulted in 10 samples in each group.

Specimen Preparation

Ethical clearance was obtained for the use of extracted human teeth for this study from the institutional review board (IEC 643/2015). A total of 50 single-rooted human teeth were selected. Soft tissue fragments and calcified debris on the specimens were removed using ultrasonic scalers. The specimens were stored in a solution of 0.2% sodium azide (Sigma-Aldrich, Steinheim, Germany) at 4°C until use. Radiographs of specimens were taken from the buccal and mesial aspect to confirm a straight, single canal with mature apices and without any calcifications. The teeth were decoronated using a diamond disc (Horico, Berlin, Germany). The working length was established by inserting a size 10-K file (Mani Inc, Tochigi Ken, Japan) into each root canal until it was just visible at the apical foramen (observed using magnifying loupes) and then subtracting 1 mm from the recorded length. The apices of all the teeth were sealed with sticky wax to prevent the flow of irrigants through them and to allow an effective reverse flow of the irrigant to simulate a closed-end system. The specimens were then randomly divided into 5 groups (n = 10) based on the irrigation regimen.

Irrigation Regimen

The irrigation regimen was as follows:

1. The NaOCl group: 5 mL 2.5% NaOCl for 1 minute after each instrument change → 5 mL 2.5% NaOCl for 1 minute → final rinse of 5 mL distilled water for 1 minute
2. The NaOCl/EDTA/NaOCl group: 5 mL 2.5% NaOCl for 1 minute after each instrument change → 5 mL 17% EDTA for 1 minute → 5 mL 2.5% NaOCl for 1 minute → final rinse of 5 mL distilled water for 1 minute
3. The NaOCl/EDTA group: 5 mL 2.5% NaOCl for 1 minute after each instrument change → 5 mL 17% EDTA for 1 minute → final rinse of 5 mL distilled water for 1 minute
4. The Dual Rinse HEDP group: 5 mL 2.5% NaOCl/9% Dual Rinse HEDP for 1 minute after each instrument change → 5 mL 2.5% NaOCl/9% Dual Rinse HEDP for 1 min → final rinse of 5 mL distilled water for 1 minute
5. The distilled water group: 5 mL distilled water for 1 minute after each instrument change → final rinse of 5 mL distilled water for 1 minute

Root canals were cleaned and shaped using the rotary ProTaper system (Dentsply Sirona Endodontics, Tulsa, OK) according to the manufacturer's instructions up to a size of F3. Irrigation was performed using a 27-G side-vented needle (Vista Dental Inc, Racine, WI), which was inserted 1 mm short of the working length. After the final irrigation regimen, the root canals were dried with paper points (Dentsply Sirona Endodontics).

Biodentine was then mixed according to the manufacturer's instructions and placed in the canal using an amalgam carrier and condensed with hand pluggers (Hu-Friedy, Chicago, IL). Obturated roots were then radiographed in the buccolingual and mesiodistal directions to ensure that the canals were densely obturated without any voids. All the teeth were stored at 37°C in 100% humidity for 1 week to allow for complete setting of Biodentine.

Pushout Bond Strength Measurement

Each root was embedded in cold cure acrylic (Dentsply India, Gurgaon, India) and sectioned horizontally in the middle third using a hard tissue microtome (Leica Biosystems, Nussloch, Germany) under continuous water cooling to obtain a slice of 1.5 ± 0.1 mm thickness. The root canal diameter as well as the height of each slice was recorded using a digital caliper. The adhesion surface area was calculated by the following equation: adhesion surface area (mm^2) = D1 + D2/2 $\times \pi \times$ h, where D1 and D2 are the largest and smallest canal diameter, respectively, π is the constant 3.14, and h is the thickness of the root slice. The pushout test was performed using a universal testing machine (Instron, Norwood, MA). The force was applied in the apicocoronal direction at a crosshead speed of 1 mm/min using stainless steel plungers of 0.6 mm positioned so that they contacted only the filling