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Original Article

Comparative Evaluation of Pushout Bond Strength of Biodentine after Root Dentin Conditioning with Different Irrigating Solutions- An *In Vitro* Study

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Abstract

Introduction: Sodium hypochlorite (NaOCl) is the main irrigant used to clean the root canal system. Chelating agents are used as additional means to condition the root dentin. The aim of this *in vitro* study is to evaluate and compare the effect of NaOCl in conjunction with Etidronic acid and Chlorhexidine on pushout bond strength of biodentine.

Materials and Methods: Single root canals of 30 extracted, mature human teeth were divided into three groups (n = 10) and enlarged using rotary instruments. Canals were irrigated according to the irrigation regimen: Group A (n = 10)–control group- distilled water. Group B (n = 10)- 2.5% NaOCl +9% HEDP. Group C (n = 10)- 2.5% NaOCl for 1 min-5 ml saline-2% chlorhexidine. Each sample was 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 Chi-square to find the significance of study parameters on categorical scale. Analysis of variance/Tukeys *post hoc* analysis to test the intergroup analysis.

Results: The pushout bond strength of Biodentine was significantly higher when the root canal was irrigated with 2.5% NaOCl/9% HEDP (9.45 ± 0.35 MPa) than with 2.5% NaOCl/saline/2% Chlorhexidine (8.27 ± 0.52 MPa). The lowest pushout bond strength values were found with distilled water irrigation (7.21 0.50.37 MPa). NaOCl+ HEDP showed significantly higher pushout bond strength when compared with other groups (P < 0.05).

Conclusion: Irrigation with 2.5% NaOCl/9% HEDP significantly improved the pushout bond strength of Biodentine to the root canal dentin.

Key words: Biodentine, EDTA, HEDP, Pushout bond strength, Smear layer, Sodium hypochlorite

INTRODUCTION

Endodontic therapy aims at achieving long-term retention and function of the tooth. Cleaning and shaping is very important step in root canal therapy. Studies have shown that large areas of root canal walls are left untouched by hand and rotary instruments during canal preparation. This shows the importance of irrigating solutions in cleaning and disinfecting the root canal system.

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Various irrigating solutions are used such as sodium hypochlorite (NaOCl), Chlorhexidine, Etidronic acid (HEDP), and hydrogen peroxide.[1]

NaOCl is one of the most accepted and widely used endodontic irrigants since 1920 as for its antibacterial activity as for its capacity of dissolving organic tissue. When NaOCl reacts with organic debris, it leads to a formation of hypochlorous acid (HOCl) which has an antimicrobial effect. HOCl disrupts the microbial metabolism within the bacterial enzyme by oxidation of sulphydryl groups present in the bacteria.[2]

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Chlorhexidine gluconate (CHX) is another endodontic irrigation solution that has been used to disinfect root canals. CHX has substantive and potent antimicrobial activity against some resistant bacteria. It has been indicated that the use of combination of NaOCl and CHX during root canal treatments decreases the bacterial load more efficiently, and this reduction is significant compared to use of NaOCl alone.[3]

Etidronic acid or 1 -hydroxyethane 1,1 -diphosphonic acid (HEDP) is a nitrogen-free bisphosphonate. An etidronate is a salt of etidronic acid, in which the anions are bound to the cations of HEDP. HEDP is a calcium chelator, averts the accumulation of smear layer and hard tissue debris. This single combined solution irrigation concept can have commendatory effects on the adhesion of various types of sealers to root dentine.[4]

The next important step after cleaning and shaping is obturation. The objective of obturation is to give a hermetic seal of the root canal system with an inert biocompatible stable filling material. Biodentine has an extensive range of applications including endodontic repair (root perforations, apexification, resorptive lesions, and root-end filling material in endodontic surgery).

Biodentine (Septodont, Saint Maur des Fosses, France) is a tricalcium silicate developed by Septodont's research group as a new range of dental cement that exhibits superior mechanical properties besides biocompatibility and bioactivity. Whenever the original dentin is damaged it is used as a dentin replacement material. Biodentine has a comparatively short setting time of around 12 min.

The pushout bond strength test estimates 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 canal dentin.

There are three possible mechanisms by which the bond failure can occur; cohesive, adhesive, and mixed failure. Adhesive failure occurs between the root canal dentin wall and Biodentine interface. Cohesive failure occurs within the Biodentine. Mixed failure includes both the failures between root canal dentin wall and Biodentine and failure within Biodentine.[1]

Thus, this study was planned to evaluate and compare effect of NaOCl in conjunction with etidronic acid and chlorhexidine on pushout bond strength of biodentine.

MATERIALS AND METHODS

Inclusion criteria 30 single-rooted single canal human teeth extracted for periodontal reasons devoid of any caries, endodontic treatment, or immature apices were used for the study. The presence of caries, root cracks or perforations, previous endodontic treatment, calcifications, or obstructions in the root canal morphology were excluded from the study.

Thirty single-rooted single canal extracted for periodontal reasons were selected. All soft tissue remnants on the root surface were cleaned and debris removed with the help of ultrasonic scaler and teeth were stored in distilled water until use. The samples were decoronated transversely 1 mm coronal to cementoenamel junction using diamond disc. The working length was established using 10K file until it was just visible at the apical foramen and then subtracted 1 mm from recorded length. The apices of all teeth were sealed with sticky wax to prevent the flow of irrigant through them and to allow effective reverse flow of irrigant to simulate closed-end system.

Solution preparation -sixty percent aqueous HEDP solution was obtained from a commercial source. This was mixed with ultrapure water to a resultant concentration of 9% HEDP. And this solution was mixed with 2.5% of NaOCl in 1:1 ratio to obtain a mixture of HEDP and NaOCl in a chemical laboratory.

The specimens were then divided randomly into three groups depending on irrigation regimens. Irrigation regimens

- Group A (n = 10)–control group- 5 ml distilled water used for 1min after each instrument change
- Group B (n = 10)- 5 ml 2.5% NaOCl +9% Etidronic acid (HEDP) used for 1min after each instrument change then final rinse with distilled water
- Group C (n = 10)-5 ml 2.5% NaOCl for 1 min-5 ml saline-2% chlorhexidine used for 1 min after each instrument change then final rinse with distilled water

The biomechanical preparation of all the samples was then carried out. The apical preparation was done upto #20k file. All samples were cleaned and shaped using Neoendo rotary file system up to size 20 taper 0.06. With every change in instrument irrigation was performed using a 27 gauge needle by inserting it 1mm short of working length as per the irrigation regimen. After final irrigation, Biodentine was mixed according to manufacturer's instructions and placed in canal with a hand plugger in all the samples. All the samples were then placed in 100% humidity for 1 week to allow for complete setting of biodentine. Then, each sample was divided into three parts by sectioning them horizontally using a diamond disc and a middle 3rd section of 1.5 mm thickness was obtained from each sample.

The push-out test was then performed using universal testing machine. The force was applied with a stainless steel plunger, positioned so that it contacted only the filling material until bond failure occurs. The crosshead speed was 1 mm/min.

Area-4.241 mm^2 Formula for pushout bond strength (MPa) = Pushout load (N) Area of bonded interface (sq/mm) Where Area of bonded interface (sq/mm)= $2\pi rh$ π =3.1416, r= radius of perforated cross section, h= height of perforation.

Fractographic Analysis

After testing all samples were subjected to stereomicroscopic at ×40 magnification for the evaluation of bond failures. The modes of bond failures were categorized as follows: (1) Adhesive failure between the root canal dentin wall and Biodentine interface (2) Cohesive failure within the Biodentine (3) Mixed failure.

Statistical Analysis

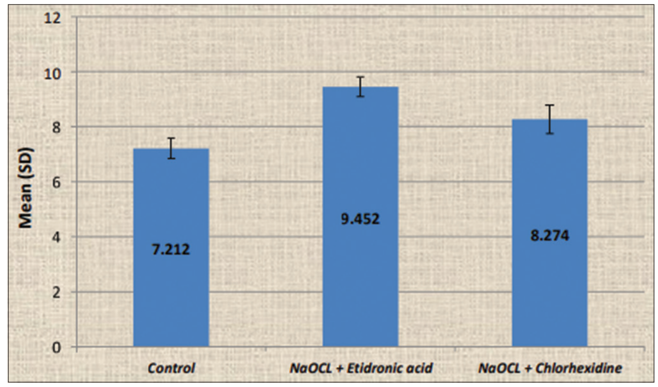
The level of significance was fixed at $P = 0.05$ and any value less than or equal to 0.05 was considered to be statistically significant. Chi-square analysis was used to find the significance of study parameters on categorical scale. Analysis of variance (ANOVA) was used to find the significance of study parameters between the groups (inter-group analysis). Further *post hoc* analysis was carried out if the values of the ANOVA test were significant. The Statistical software IBM SPSS statistics 20.0 (IBM Corporation, Armonk, NY, USA) was used for the analyses of the data and Microsoft Word and Excel were used to generate graphs, tables, etc.

RESULTS

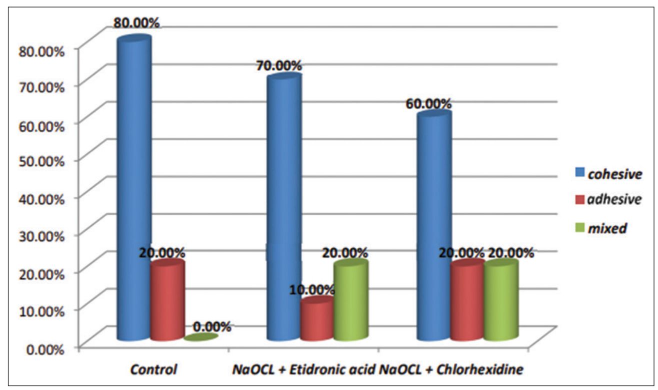
On intergroup comparison, Graph 1 (NaOCl+ HEDP) showed significantly higher pushout bond strength (9.452 MPa) when compared with other groups ($P < 0.05$). Group A (Distilled water) had significantly lower pushout bond strength in comparison with the other groups (7.212 MPa) ($P < 0.05$). Group C (NaOCl + Chlorhexidine) showed significantly lower pushout bond strength (8.312 MPa) than Group A ($P < 0.05$).

Fractographic Analysis

On intergroup comparison in Graph 2, Group A, the mode of bond failure was observed to be 20% adhesive and 80% cohesive. In Group B 10% was adhesive, and 70% was cohesive and 20% was mixed. In Group C 20% was adhesive, 60% was cohesive and 20% was mixed. Overall, in all the experimental groups, adhesive failure was observed in 5 of 30 specimens (16.66%), cohesive failure in 21 of



Graph 1: Intergroup comparison of push out bond strength in terms of {Mean (SD)} among all the groups using ANOVA test



Graph 2: Intergroup comparison of fracture mode among all the 3 groups using Chi-square test

30 specimens (70%), and mixed type of failure in 4 of 30 specimens (13.33%).

DISCUSSION

The mixture of NaOCl and HEDP has the ability to reduce the formation of smear layer during rotary root canal instrumentation to an extent similar to the standard use of NaOCl followed by EDTA while also reducing the accumulation of hard tissue debris. In addition, HEDP does not affect the dissolution activity and antimicrobial properties of NaOCl.[1]

Group A (HEDP+NaOCl) showed the highest mean push out bond strength (7.2120 MPa) which was statistically significantly higher than the Group A (control group) and Group C(NaOCl + CHX) ($P < 0.001$).

This was attributed to the fact that HEDP has no adverse effect on the hydration properties of calcium silicate cements. A 2.5% NaOCl concentration was selected because when mixed with 9% HEDP this combination has been shown to reduce the dentin debris accumulation and to maintain the antimicrobial and tissue dissolution properties of NaOCl alone.[5]

Ulusoy *et al*. stated that there was no significant difference between the 18% HEDP and 9% HEDP in terms of elimination of the smear layer. Therefore, lower (9%) concentrations of this solution can be more safely used for root canal final irrigation to prevent the deleterious effects of high concentration.[6]

The result in the present study showed that Group C (Chlorhexidine + NaOCl) had poor pushout bond strength than Group B (NaOCl +HEDP). These results were in accordance with the results of Hong *et al*. who showed that 2% Chlorhexidine reduced the push-out strength of calcium silicate cements.[7]

This was attributed to the fact that when chlorhexidine was used as an irrigant, there was no apparent crystal structure on the surface of calcium silicate cements. The surface crystals had thin plate structures, and their size was decreased almost to one tenth. The silicon was detected along with calcium, oxygen, and carbon. It proved that they were not the typical calcium hydroxide crystals. These findings may explain why the push-out strength of the CHX groups was significantly reduced.[8]

In the present study Group A showed the least pushout bond strength than Group B and Group C. The possible reason might be that the calcium silicate cements set via hydration reaction. When they are used for endodontic purpose, the hydraulic cements adherence with the surrounding dentin is necessary. Thus, during the setting reaction water availability for calcium-silicate cements plays an important role in determining the final strength of the completely set material. Thus, biodentine in the control group showed reduced push–out bond strength.[9]

However, Graph B showed the distribution of failure rates. Analysis of the mode of bond failure showed 70% cohesive type of bond failure. This may be attributed to the good adhesion of Biodentine to the root canal walls because the size of the particles is finer compared to other calcium silicate cements, which, in turn, enhances the infiltration of the cement into the dentinal tubules.[10]

When Biodentine gets exposed to NaOCl, it increases the size and number of calcium hydroxide crystals and also releases calcium. Thus, building up of calcium hydroxide enhances the pH of Biodentine resulting in greater sealing ability of the material.[11]

Singh *et al*. showed that calcium and silicon ion uptake into dentin leading the formation of tag-like structures in Biodentine was higher than MTA.[12]

This vitro study has limitations, as the tests were carried out in single-rooted teeth, with specific dimensions, under a static compressive loading applied at a single point and at a fixed angulation. Thus, dynamic or fatigue behavior cannot be inferred. The ultimate clinical decision-making should also consider patient-related variables such as occlusion, masticatory force, and parafunctional habits, to maximize the long-term prognosis.

CONCLUSION

Within the limitations of this *in vitro* study, it can be concluded that -The pushout bond strength of biodentine was differentially influenced by the various irrigation regimens. –The use of the combination of 2.5% NaOCl/9% HEDP for 1 min enhanced the bond strength of Biodentine to the root canal dentin compared to the use of 2.5% NaOCl and 2% chlorhexidine. Analysing the modes of failure of these resin cements it can be concluded that Biodentine showed good adhesion to the root canal walls, proving its better efficiency clinically.

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