RSBO

ISSN:
Electronic version: 1984-5685
RSBO. 2017 Apr-Jun;14(2):67-73

Original Research Article

Sealing ability of materials used as protective cervical barrier in internal tooth bleaching

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Received for publication: August 25, 2016. Accepted for publication: May 10, 2017.

Keywords:
root resorption; dental cements; tooth bleaching; dental leakage.

Abstract

Introduction: The use of a protective cervical barrier (PCB) is very well established to perform a safe internal bleaching; however, there is still no consensus on which material has the best sealing ability. **Objective:** This *in vitro* study aimed to evaluate the apical and linear sealing of different PCB materials placed during internal bleaching. **Material and methods:** This study had two study factors: PCB positioning, divided at two levels (cement-enamel junction [CEJ] and 1mm above the cement enamel junction [CEJ+1]); and PCB material, divided at eight levels (resin composite [RC], glass ionomer cement [GIC], resin-modified glass ionomer cement liner [LRGIC], restorative resin-modified glass ionomer cement [RRGIC], zinc phosphate cement [ZPC], eugenol-free zinc oxide cement [ZOC], provisional filling resin [PFR] and gutta-percha as control [GUT]). Response variables were apical and linear sealing obtained through dye penetration and analyzed with a digital microscope. Data were subjected to two-way analysis of variance followed by Tukey test ($p<0.05$). **Results:** The main factor for both apical and linear sealing was the type of material ($p<0.01$), regardless of their position. RC and ZPC presented the worst sealing values ($p<0.05$). The Spearman rank correlation coefficient revealed a positive correlation between the apical and linear leakage. **Conclusion:** The results suggest that RC and ZPC must be avoided as a PCB during internal bleaching procedures.

Introduction

In most of non-vital teeth discoloration cases, the treatment of choice is the internal bleaching, since this is a more conservative approach than direct or indirect restorations [2, 17] and provides high success rate, varying from 60 to 90% [7], depending on the type of discoloration and bleaching agent used [8]. However, the internal bleaching has been related to external cervical resorption (ECR) by several authors [7, 14, 18, 19], which is caused by the inflow of oxygen free radicals through dentin pathways into periodontal ligaments, starting an inflammatory response that may lead to the ECR [7]. Moreover, this process can be intensified due to the morphology of the cement-enamel junction (CEJ), which may present exposed dentin areas to the periodontal tissues, resultant from different relationships between enamel, dentin, and cementum [14].

To prevent the ECR, the use of a protective cervical barrier (PCB) was proposed to block the passage of oxygen free radicals into dentin [6, 20]. Some authors observed that in 255 teeth treated with PCB and internal bleaching, no cases of ECR were observed [1]. Despite of those results, still there is no consensus in the literature regarding to the material of choice for PCB. An ideal material for PCB purposes must not only offer a good sealing ability, but also may be easily removable, allowing access to the root canal after the bleaching procedure, and may not be deleterious to adhesive restorations that will be placed after internal bleaching. In the past, some authors suggested the use of eugenol-based intermediate restorative material for PCB; however; it was observed that eugenol is able to compromise resin composite polymerization [5, 13].

So, to provide evidences regarding to properties of different materials used as PCB, this study aimed to evaluate the sealing ability of some materials through dye penetration evaluated by digital microscope.

Material and methods

Experimental design

The study factors were PCB positioning, divided at two levels (at cement-enamel junction [CEJ] and 1mm above the cement enamel junction [CEJ+1]); and PCB material, divided at eight levels (resin composite [RC], glass ionomer cement [GIC], resin-modified glass ionomer cement liner [LRGIC], restorative resin-modified glass ionomer cement [RRGIC], zinc phosphate cement [ZPC], eugenol-free zinc oxide cement [ZOC], provisional filling resin [PFR] and gutta-percha as control [GUT]) (table I). Response variables were apical and linear sealing, obtained through dye penetration and analyzed with a digital microscope. The experimental sample consisted of 112 bovine incisors assigned to one of the sixteen groups described above (n = 7).

Table I – Materials used in PCB in the experimental groups

Group	Material	Material type	Composition
RC	Filtek™ Z250 (3M/ESPE, St. Paul, MN, USA)	Micro hybrid Resin Composite	Zirconium/Silica, BIS-GMA, UDMA, BIS-EMA
GIC	VIDRION R (SS-White, Rio de Janeiro, RJ, Brazil)	Conventional Glass Ionomer cement	Powder: Sodium Fluorosilicate Calcium Aluminum, Barium sulfate, polyacrylic acid, pigments Liquid: Tartaric Acids, Distilled water

Group	Material	Material type	Composition
LRGIC	VITREBONDTM (3M/ESPE, St. Paul, MN, USA)	Lining Resin-modified Glass Ionomer Cement	Powder: Fluoroaluminiumsilicate glass and photoinitiator (camphorquinone). Liquid: polialcenoic acid copolymer, photoinitiator (camphorquinone), HEMA (hydroxyethyl methacrylate) and water
RRGIC	VITREMERTM (3M/ESPE, St. Paul, MN, USA)	Restorative Resin-modified Glass Ionomer Cement	Powder: Fluoroaluminiumsilicate crystals, potassium persulfate, ascorbic acid, and pigments. Liquid: polialcenoic acid, methacrylate groups, water, HEMA, camphorquinone
ZPC	CIMENTO DE ZINCO (SS-White, Rio de Janeiro, RJ, Brazil)	Zinc Phosphate Cement	Powder: Zinc oxide, magnesium oxide, dyes. Liquid: phosphoric acid, aluminum hydroxide, zinc oxide, and distilled water
ZOC	COLTOSOL (Coltene-Vigodent, Rio de Janeiro, RJ, Brazil)	Eugenol-free Zinc Oxide cement	Paste: Zinc oxide, zinc sulfate, calcium sulfate, polyvinyl acetate, menthol and dibutyl phthalate
PFM	CLIP F (VOCO, Cuxhaven, Germany)	Provisional Filling Material	Diurethane dimethacrylate, BHT, polymers and fluorine
GUT	GUTTA-PERCHA+ FILLAPEX (Angelus, Paraná, Brazil)	Cones and resin cement to root canal filling	Natural gutta-percha and Zinc Oxide. Salicylate resin, thinner resin, natural resin, Bismuth oxide, nanoparticulate silica, mineral trioxide aggregate, pigment

* Data according to the manufacturers' information

Preparation of samples

Bovine incisors previously stored in 5% thymol were analyzed in stereomicroscope for the detection of fractures and/or cracks, which when present made the sample impractical. The samples were measured using a digital caliper, and sectioned 3mm apically and 6mm coronally to the buccal cement-enamel junction (CEJ) on the cutting machine (Isomet 1000TM - Buehler, Lake Bluff, IL, USA). Remnants of pulp tissue were removed with a #40 K-file and irrigated with 2% sodium hypochlorite solution. The root canal was enlarged with a size #4 Gates Glidden bur at low speed and washed with deionized water and air-pressure water. In all specimens, a base of 1mm of resin composite was placed in the apical area to receive the different protective material over its surface.

Placement of protective cervical barrier (PCB)

All root canals were cleaned with 17% EDTA (INODON, Porto Alegre, Brazil) prior the placement of PCB. The external position of buccal CEJ was checked with a periodontal probe and this measuring were transferred to the pulp chamber to guide the position of PCB. The materials were placed into the pulp chamber at the CEJ level (CEJ), or 1mm above (CEJ+1), on the buccal surface, from which it was condensed in towards coronal position in palatal direction, and towards the proximal surfaces to prevent the diffusion of hydrogen peroxide and dye at this level (figure 1). All materials were handled and placed according to the manufacturer's instructions. To minimize the shrinkage of polymerization, the resin composite was applied by incremental technique and light-cured (Blue Star 2 1000mW/cm² – Microdont, São Paulo, SP, Brazil) In control group, a conventional endodontic treatment was performed (Gutta-percha and Fillapex – Angelus, Londrina, PR, Brazil). All procedures were performed by the same operator.

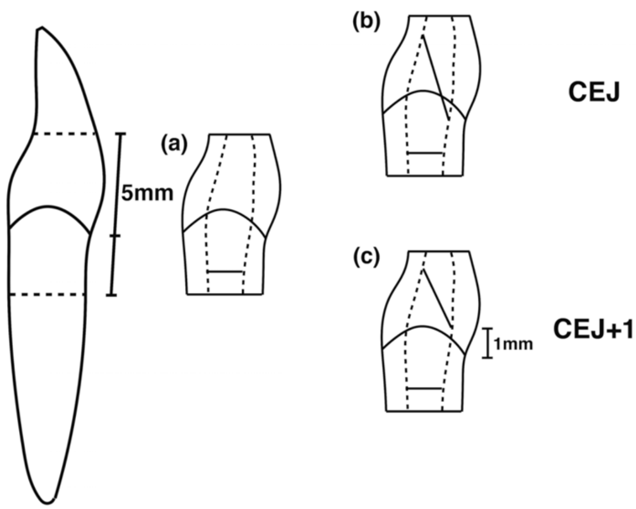

Figure 1 – Specimen preparation: The bovine teeth were sectioned transversely 5 mm above and 3 mm below CEJ (a); after that, materials were placed into the pulp chamber on the buccal surface at CEJ level (b); or 1mm above (c)

Internal bleaching

The internal bleaching was performed immediately after placement of the PCB. The walking bleach technique [15] was performed with a mixture of sodium perborate and a solution of 30% hydrogen peroxide (Pharmácia Specifica, Bauru-SP, Brazil). The cavities were sealed with resin composite and the specimens were immersed in deionized water and stored in an oven for seven days at 37°C.

Infiltration test

After bleaching, the cavities were rinsed for 60 seconds in air-pressure water and the specimens were stored for 7 days again in an oven to eliminate the residual oxygen that might interfere with the dye infiltration. The outer surface of the specimen was protected and sealed previously to the placement of the dye into the pulp chamber. The 2% basic fuchsine solution was mixed with carbonated water in a 1:1 ratio, trying to emulate the effect of hydrogen peroxide. This solution was placed in a standard amount into the pulp chamber and after sealing, the specimen was stored in an oven for 48hrs.

Analysis of infiltration

After the storage time, the specimens were sectioned at the buccal-lingual direction for evaluation of vertical dye penetration, and at the mesial-distal direction for evaluation of horizontal dye penetration (figure 2). The dye infiltration was analyzed at vertical (from PCB to root outer surface) and horizontal (between PCB and CEJ) planes. For the analysis, both specimen's cuts were photographed through a portable digital microscope (figure 3), (Dino-Lite Plus AM-313T, AnMo, Taiwan) together with an appropriate software (DinoCapture 2.0).

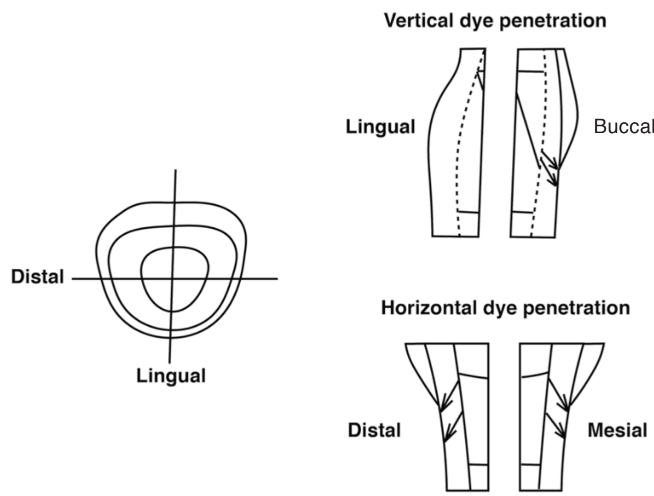

Figure 2 – Specimen sectioning for evaluations: After the storage time, the specimens were sectioned in the buccal-lingual direction for evaluation of vertical dye penetration, and sectioned in the mesial-distal direction for evaluation of horizontal dye penetration

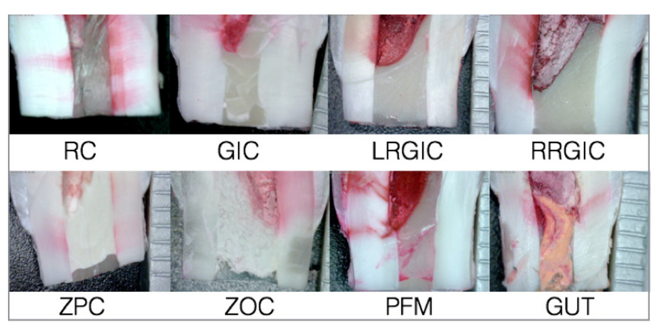

Figure 3 – Illustrative photos of the materials tested at the CEJ level

The leakage through the apical direction (vertical plane) was assessed in scores ranging from:

0 – No infiltration;
1 – Infiltration up to 1/3 of PCB;
2 – Infiltration up to 2/3 of PCB;
3 – Infiltration throughout the length of PCB.

The amount of linear dye infiltrated (horizontal plane) was visually evaluated in scores ranging from:

0 – No Infiltration, 0 %;
1 – Infiltration up to 25 % of the total distance;
2 – Infiltration up to 50 % of the total distance;
3 – Infiltration up to 75 % of the total distance;
4 – Infiltration up to 100 % of the total distance.

All measurements were made by three blinded and calibrated examiners (K > 0.86).

Statistical analysis

Data were submitted to two-way analysis of variance (ANOVA), followed by Tukey's test for individual comparisons ($p<0.05$). Spearman rank correlation test was also performed between the apical and linear sealing.

Results

No significant difference occurred in the PCB positioning, while differences occurred regarding the material type, but without interaction between them. The values of apical and linear infiltration are shown in table II and III.

Table II – Comparison between groups in relation to the apical dye penetration (Tukey test)

Material	CEJ	CEJ+1
RC	2.43 (±1.13)^{bc}	2.57 (±0.79)^{c}
GIC	0.86 (±1.07)^{a}	0.29 (±0.49)^{a}
LRGIC	0.43 (±0.79)^{a}	0.29 (±0.76)^{a}
RRGIC	0.71 (±0.76)	0.71 (±0.76)^{a}
ZPC	2.43 (±0.79)^{bc}	3.00 (±0.00)^{c}
ZOC	0.14 (±0.38)^{a}	0.43 (±0.53)^{a}
PFM	0.14 (±0.38)^{a}	0.00 (±0.00)^{a}
GUT	0.86 (±1.21)^{a}	1.14 (±0.69)^{ab}

Different superscript letters indicate statistically significant differences between columns; $p<0.05$ (Tukey test)

Table III – Comparison in relation to the linear dye penetration (Tukey test)

Material	CEJ	CEJ+1
RC	2.71 (1,50)^{c}	2.43 (0.53)^{bc}
GIC	0.43 (0.53)^{a}	0.14 (0.38)^{a}
LRGIC	0.14 (0.38)^{a}	0.29 (0.76)^{a}
RRGIC	0.29 (0.49)^{a}	0.43 (0.53)^{a}
ZPC	2.43 (1.13)^{bc}	3.43 (0.79)^{c}
ZOC	0.14 (0.38)^{a}	0.43 (0.53)^{a}
PFM	0.29 (0.49)^{a}	0.00 (0.00)^{a}
GUT	1.00 (1.53)^{ab}	0.43 (0.79)^{a}

Different superscript letters indicate statistically significant differences between the columns; $p<0.05$ (Tukey test)

For apical infiltration, the lowest values of microleakage were found in Clip F, Coltosol, Vitrebond, Vitremer, Vidrion R with no significant differences between them. The control group showed no significant differences with these materials, but presented lower leakage than composite resin groups and zinc phosphate cement.

The same pattern was observed for linear infiltration. The lowest values of infiltration were found in Clip F, Coltosol, Vitrebond, Vitremer, Vidrion R with no significant differences between them. The higher infiltration was evidenced by Z250 composite resin and zinc phosphate cement.

The Spearman rank correlation test showed that there is positive correlation (0.911) between apical and linear infiltration ($p<0.05$).

Discussion

The fuchsine was combined with the carbonate water, but not with the bleaching agent, because hydrogen peroxide made the dye infiltration analysis impossible. The analysis of only one longitudinal surface of the sample is another limitation of the present study.

Material used as Protective Cervical Barrier (PCB)

Due to the importance of physicochemical properties and different sealing capacities, different materials are suggested to perform the PCB. In the present study resin composite and zinc phosphate cement had the worse results.

Polymerization shrinkage may be the main cause of failure in the sealing ability of resin composite. It is very well established that resin composite's polymerization shrinkage can determine voids between material and tooth structure, especially when a great volume of composite is light-cured at once. In addition to this, the lack of adhesive system may have contributed significantly to gap formations and dye penetration. Other study [20] observed that resin composites in association to its adhesive systems can develop a satisfactory sealing ability. However, its clinical application could avoid the contact of hydrogen peroxide in some areas of the teeth. Besides, well adhered resin composites may not be easily removable from root canal if fiber posts cementation is needed after bleaching procedure.

The zinc phosphate cement also showed unfavorable results in other studies with human teeth [3, 10]. It was suggested that this material suffers dissolution when subjected to tooth whitening, which can determine the higher amount of dye penetration that was observed in the present study.

Glass ionomer cements have the potential to chemically bond to tooth structure, and therefore, GICs have been recommended as an effective PCB previously to whitening procedure because it can be left after bleaching, serving as a base for the final restoration [17]. In the present study, the material showed excellent results of sealing in bovine teeth, and no statistically significant differences could be found between the conventional and resin-modified GIC, either liner or restorative.

Some authors reported that Cavit, a material similar to Coltosol, promoted better sealing than zinc phosphate cement [12] and IRM [9]. Other studies with human teeth, also observed that the Coltosol showed excellent sealing results, due to its ability to absorb water during the final setting stages and the present study corroborate these results [4, 10].

Clip F, the resin-based provisional materials based on dimethacrylates showed favorable results in the present study. The main advantage of Clip F is that no adhesive system is necessary and this material becomes flexible after polymerization allowing easy removal of the cavity. A study with human teeth tested the sealing of different provisional materials and stated that the Bioplic (Biodynamics), resin-based material similar to Clip F, showed the best marginal sealing and it was associated with lower water absorption, solubility, and mass loss [16].

Differently from other studies, the control group with gutta-percha and resin cement, in this study, showed acceptable results in relation to dye penetration. Although in some specimens the gutta-percha sealing has been effective in apical sealing, PCB is recommended, because in some groups a severe infiltration was observed. The findings corroborate with other studies that suggested a protective barrier must be placed by the fact that the endodontic material alone is not enough to prevent the passage of the peroxide [6].

Position of the Protective Cervical Barrier (PCB)

Different positions of PCB in relation to the CEJ have been recommended and analyzed. Some authors recommended that the PCB should be placed at or slightly coronal regarding to the buccal and proximal CEJ to ensure that hydrogen peroxide does not overflow to external root area [11, 20]. Also, the PCB must not interfere with the whitening process in the cervical region. From the present results, the variable "PCB positioning" did not influence on the sealing ability of different PCB. It is important to consider that the dentinal tubules orientation in the coronal third of the root run in an oblique direction to the cervical portion of the crown, so the tubules ending in CEJ starts in more apical position within the root canal, explaining the results found [11].

Conclusion

The sealing capability of PCB varied according to the material applied, regardless of the PCB height. Resin composite and zinc phosphate cement must be avoided.

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