Original Article

An *in vitro* comparative evaluation of intraorifice barriers and bleaching agents on the fracture resistance of the endodontically treated anterior teeth

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Abstract

Aim: This study aimed to evaluate and compare the impact of different bleaching agents on the fracture resistance of endodontically treated teeth when using either GC Fuji type 2 glass ionomer cement (GIC) or Shofu Glass Ionomer RX EASE as intraorifice barriers (IOB).

Materials and Methods: A total of 80 single-rooted human maxillary central incisors were prepared and obturated. Three millimeters of gutta-percha was then removed from the orifice. The specimens were divided into two primary groups based on the type of IOB material used: GC Fuji type 2 GIC and Shofu Glass Ionomer RX EASE ($n = 40$). Each group was further divided into four subgroups based on the bleaching agent used: Carbamide peroxide (CP) 37%, sodium perborate (SP), hydrogen peroxide (HP) 35%, and distilled water used as the control ($n = 10$). The teeth were subjected to fracture resistance testing.

Results: The study found that the order of root fracture resistance was control > CP > SP > HP. There was no statistically significant difference in fracture resistance between GC Fuji type 2 GIC and Shofu Glass Ionomer RX EASE when used as IOB materials.

Conclusion: The study concluded that the choice of bleaching agent significantly affects the fracture resistance of endodontically treated teeth. It was observed that fracture resistance is lowest with HP, followed by SP and CP. Both GC Fuji type 2 Glass Ionomer and Shofu Glass Ionomer RX EASE are effective as IOB.

Keywords: Endodontically treated teeth; fracture resistance; glass ionomer cement; intraorifice barrier

INTRODUCTION

In modern society, the esthetic appearance of teeth has become increasingly important.[1] Discolored teeth are a common cosmetic problem that may require treatment, such as bleaching.[2] It is essential for dental professionals to diagnose and treat the underlying cause of tooth discoloration accurately.[3]

Bleaching involves using a chemical agent to lighten the color of teeth by oxidizing organic pigments.[4] The most commonly used bleaching agents for whitening root canal-treated teeth are sodium perborate (SP) which contains around 95% perborate when fresh, 3%–35% hydrogen peroxide (HP), and 3%–45% carbamide peroxide (CP).[5] To prevent the leakage of bleaching agents into the periodontium, a protective barrier is recommended over the coronal area of the root canal filling. Various materials have been tested as an intra-coronal seal to prevent microleakage, including amalgam, Cavit, EBA, intermediate restorative material, composite resin, glass

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ionomer cement (GIC), and mineral trioxide aggregate.[6] GIC is commonly used as a coronal barrier material because of its adhesive and cariostatic properties.[7]

However, various studies have reported conflicting results regarding the effect of bleaching agents on the fracture resistance of teeth following endodontic treatment, as well as a decline in bond strength to the tooth structure after bleaching.[8,9]

Rationale

The objective of this study is to assess and compare the effect of different bleaching agents on the strength of endodontically treated teeth utilizing either GC Fuji type 2 GIC or Shofu Glass Ionomer RX EASE as intraorifice barriers (IOB).

The findings of this study could provide valuable information for dental professionals regarding the selection of bleaching agents and IOB materials to maintain the structural integrity of endodontically treated teeth. The study could also contribute to the development of better clinical guidelines for dental practitioners.

MATERIALS AND METHODS

Eighty single-rooted human maxillary central incisors with straight roots were chosen for the study extracted due to periodontal disease. Endodontic access cavity preparations were performed on all teeth using a high-speed rotary handpiece (Nakanishi, Japan, NSK Dental Corp) and a round diamond bur (BR-41) and safe end bur (EX-24) (DIA burs, Mani Inc. Japan). Working length was determined by using a 15 K file (Mani Inc. Japan).

The root canals were cleaned and shaped using rotary ProTaper Universal files up to F5 (Dentsply Maillefer, Ballaigues, Switzerland). One milliliter of 3% sodium hypochlorite solution (Prime Dental Products Pvt. Ltd., India) was used to irrigate the canal at each instrument change. Following the completion of root canal instrumentation, the smear layer was removed using 5 mL of 17% ethylenediaminetetraacetic acid for 1 min. The canals were then irrigated with 5 mL of regular saline and dried using paper points. For obturation, F5 master cones (Dentsply, Maillefer, Ballaigues, Switzerland) and accessory gutta-percha points were utilized, along with AH Plus Sealer (Dentsply De Trey, Konstanz, Deutschland), and the cold lateral compaction technique was employed to finish the procedure. The 3 mm of coronal portion root canal fillings was removed with a #5 Gates Glidden drill (Mani Corp, Japan), leaving the orifice's widest point with a uniform 1.3 mm diameter. The depth of the cavity was confirmed using a William's periodontal probe [Figure 1].

The obturated specimens were categorized into two main groups according to the IOB material used over the root canal filling: GC Fuji type 2 GIC and Shofu Glass Ionomer RX Ease ($n = 40$). Each group was then divided into four further subgroups according to the bleaching agent used: CP 37% (FGM Whiteness Super-endo), HP 35% (Opalescence Endo; Ultradent Products), SP (Qualikems), and distilled water as the Control ($n = 10$).

A 3-mm thick layer of IOB materials was placed into each specimen's canal orifice, which was manipulated according to the manufacturer's instructions [Figure 1]. A cotton pellet was inserted in the chamber and temporarily sealed with Cavit. After 24 h, the teeth were then cleaned with distilled water. Preparation of groups was done by placing the following agents in the pulp cavities:

1. SUBGROUP A: FGM Whiteness Super-endo CP was utilized, consisting of 0.5% potassium nitrate, 37% CP, and 0.11% weight-to-weight (1100 ppm) fluoride ion. The product was applied following the manufacturer's instructions
2. SUBGROUP B: Opalescence Endo 35% HP (Ultradent Products, South Jordan, UT, USA) was employed for the "walking" bleach method. It is a preloaded gel in a syringe with a needle tip and a pH of 5. The manufacturer's guidelines were followed for application
3. SUBGROUP C: SP (Qualikems) was used in a powder form. A combination of 2 g of powder and 1 mL of distilled water was blended to produce a wet sand consistency utilizing a spatula on a glass slab. The resulting mixture was then placed into the pulp chamber with the aid of an amalgam carrier
4. SUBGROUP D: Distilled water served as the control group and received 20 µL of distilled water in the pulp cavity.

A small cotton pellet immersed in distilled water was positioned over the respective intracoronal bleaching agent. Then 2 mm of Cavit was used to fill the access cavities. The walking bleaching technique protocol was followed, and the bleaching agent was changed every 7 days for three periods. To maintain the samples' hydration during the bleaching process, they were immersed in a phosphate-buffered solution. After the bleaching procedure was completed, the specimens were incubated in a phosphate-buffered solution at 37°C and 100% humidity for 1 week. Single Bond Adhesive (3M ESPE) and Filtek Z 350 Composite Resin (3M ESPE) were used to restore the access cavities.

Fracture resistance measurement

To measure fracture resistance, each root was covered with a thin layer of light-body silicone (Flexceed putty type, GC, Japan) up to 2 mm below the cementoenamel junction to simulate the periodontal ligament. The root was then mounted in a polyvinyl chloride ring with self-cured acrylic at the 2 mm level.

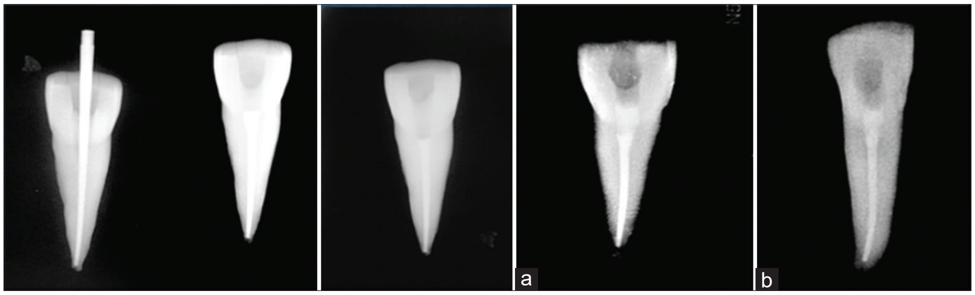


Figure 1: Obturation with F5 master cone followed by 3 mm of gutta percha removal and periapical radiograph with intraorifice barrier material GC Fuji type 2 Glass Ionomer Cement (a), Shofu Glass Ionomer RX Ease (b)

Underwater immersion at 37°C, the root was vertically loaded into the root canal at a speed of 5 mm/min until fracture using a universal testing machine. The force required to fracture the root was recorded in Newtons [Figure 2].

Data management and analysis

Microsoft Excel spreadsheet and SPSS software (Stastistical package for the Social Sciences) (version 17.0, IBM, Chicago, Illinois, USA) was used for the data analysis. $P < 0.05$ was considered statistically significant. The Shapiro–Wilk test was used to determine the normal distribution of data. The fracture resistance data were analyzed using a one-way analysis of variance (ANOVA), and pair-wise comparisons were made using the Tukey *post hoc* test. The analysis results were presented, and conclusions were drawn based on the processed data.

Table 1: Mean and standard deviation of fracture resistance for all groups

	n	Mean	SD	SE
Group 1: GC Fuji type 2 GIC				
Subgroup A-CP	10	1076.1000	118.00796	37.31739
Subgroup B-HP	10	653.4000	87.17059	27.56576
Subgroup C-SP	10	1021.6000	102.11888	32.29283
Subgroup D-distilled water	10	1403.6000	54.09292	17.10568
Total	40	1038.6750	284.05953	44.91375
Group 2: Shofu Glass Ionomer RX Ease				
Subgroup A-CP	10	1035.7000	70.34210	22.24413
Subgroup B-HP	10	626.1000	83.39524	26.37189
Subgroup C-SP	10	970.5000	79.13596	25.02499
Subgroup D-distilled water	10	1349.2000	74.05674	23.41880
Total	40	995.3750	270.36810	42.74895

SD: Standard deviation, SE: Standard deviation, GIC: Glass ionomer cement, CP: Carbamide peroxide, SP: Sodium perborate, HP: Hydrogen peroxide, GC: Global Corporation

RESULTS

The fracture strength test mean and standard deviation are presented in Table 1. The control group, consisting of endodontically treated teeth sealed with GIC and not subjected to bleaching, exhibited the highest fracture resistance value, significantly different from the other experimental groups ($P < 0.05$). The HP group reported the lowest fracture resistance values.

There was a statistically significant difference in fracture resistance between the bleaching agent groups of SP versus HP and CP versus HP ($P < 0.05$) according to the ANOVA test. However, there was no significant difference in fracture resistance value between the CP versus SP bleaching group.

In addition, no statistically significant difference was reported between the GC Fuji type 2 GIC and Shofu Glass Ionomer RX Ease as IOB, as shown in Graph 1.

Hence, the null hypothesis, which states that there is no difference in the fracture resistance of endodontically treated teeth undergoing intracoronal bleaching with different bleaching agents when conventional GC Fuji type 2 GIC and Shofu Glass Ionomer RX EASE are applied as IOB were rejected.

DISCUSSION

Tooth weakening is a common issue associated with endodontic treatment and dental bleaching. Attin *et al*. concluded that all tested bleaching agents reduced enamel hardness and fracture toughness, but the degree of reduction varied with different agents.[10]

This study evaluated the fracture resistance of endodontically treated teeth treated with three different bleaching agents using GC Fuji type 2 GIC and Shofu Glass Ionomer RX EASE as IOB.

The concept of IOB was developed by Roghanizad and Jones[11] to prevent coronal microleakage, and its favourable effects have been demonstrated in several studies.[12,13] Galvan *et al*. compared five materials used to create an intracoronal seal in endodontically treated teeth. The study found that none of the materials tested completely prevented microleakage. However, GIC and dentin bonding agent (DBA) significantly reduced coronal microleakage compared to the other materials tested. This suggests that GIC and DBA may be more effective for creating an intracoronal seal in endodontically treated teeth.[13] Employing an IOB during intracoronal bleaching can also improve fracture resistance compared to not utilizing one.[14]

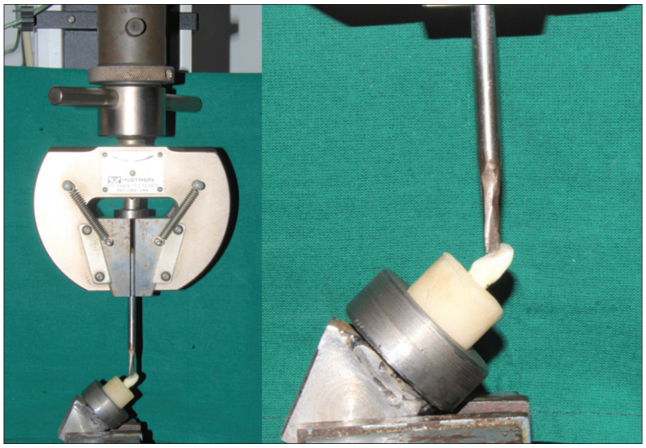


Figure 2: Sample placed in universal testing machine at an angle of 135°

Gupta *et al*. evaluated different IOB, and their impact on the fracture resistance of endodontically treated roots obturated with gutta-percha. Their findings suggest that certain types of IOB can improve the fracture resistance of these roots.[15]

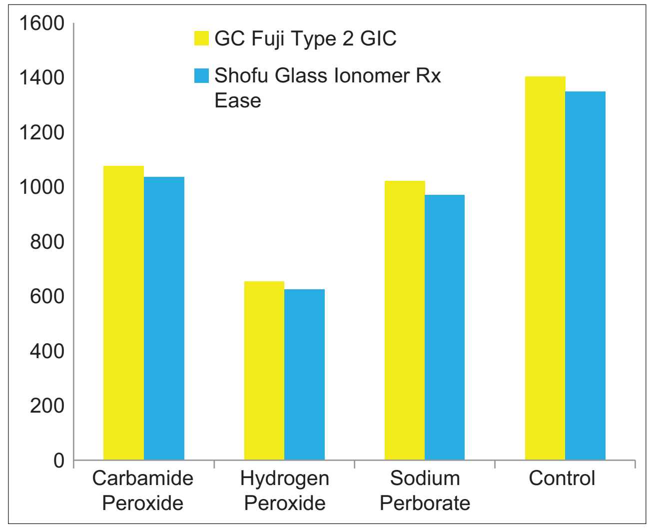
Zandbiglari *et al*. found that increasing the taper of endodontic instruments can decrease the resistance to fracture of endodontically treated roots, which may be relevant to the potential effects of bleaching on root strength.[16]

GIC is a commonly used coronal barrier material due to its modulus of elasticity values close to dentin, which can help sustain significant stress before passing the load to the root. In addition, GIC chemically adheres to the dentinal surface, providing increased strength at the dentin-cement interface.[17]

Rotstein *et al*. demonstrated that a 2-mm layer of GIC effectively prevented 30% HP solution penetration into the root canal. Using GIC as a base during bleaching can also be advantageous as it can be left in place after bleaching and serve as a base for the final restoration.[6]

The study used the walking-bleach technique and evaluated the effects of three intra-coronal bleaching agents: HP (35%), CP (37%), and SP. HP produces hydroxyl radicals that bleach teeth in the presence of iron salts.[5] It was found that dentin's ultimate tensile and shear strengths decreased substantially after intracoronal bleaching was done with 30% HP for 24 h.[18] This is also supported by the current results, given that the group that received the HP bleaching agent had the lowest fracture resistance values.

On the other hand, CP, which produces HP and urea,[19] had the highest fracture resistance values after the control group. Bonfante *et al*. found that endodontically treated teeth' resistance to fracture was not affected by bleaching with 37% CP.[20] Several possible explanations for CP's high fracture resistance value include its slow diffusion through the dentin, the low concentration of HP released, and the high pH created by ammonia produced by CP, which aids in HP deionization.[21]



Graph 1: Comparison of fracture resistance in various groups and sub-groups

SP, commonly used for nonvital tooth bleaching, decomposes in contact with water to release nascent oxygen. As compared to concentrated HP solutions, SP is easier to handle and safer.[5] Chng *et al*. reported no significant change in dentin microhardness when using SP mixed with water or 30% HP solution.[18]

The control group, used distilled water instead of a bleaching agent, and had the maximum fracture resistance values. The decrease in fracture resistance observed in the experimental groups was attributed to the bleaching agents' oxidizing action on tooth tissue, leading to collagen fiber and hyaluronic acid breakdown, reduced dentin microhardness, and decreased crown fracture resistance.[22,23]

The study used extracted single-rooted human maxillary central incisors since the upper anterior teeth discoloration was more commonly observed. Several invasive treatments have been used to whiten discolored teeth, such as placing crowns or veneers. However, using bleaching to whiten teeth is a noninvasive alternative that preserves dental hard tissue.[24]

The study's limitations include using static loading testing to evaluate fracture resistance and the need for further research using dynamic loading combined with thermocycling and clinical trials to confirm the study's results.

CONCLUSION

The study found that different bleaching agents significantly affected the fracture resistance of endodontically treated teeth. HP had the lowest fracture resistance values, followed by SP and CP. GC Fuji type 2 Glass Ionomer and Shofu Glass Ionomer RX Ease are both suitable intra-orifice barriers, with no significant difference observed between them.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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