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Fracture Resistance of Bleached Teeth Restored with Different Procedures

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This study evaluated the fracture resistance of teeth submitted to internal bleaching and restored with different non-metallic post. Eighty mandibular incisors were endodontically treated and randomly divided in 10 groups (n = 8): G1- restored with composite resin (CR), G2- CR + fiber-reinforced composite post (FRC, Everstick post, Sticktech) cemented with resin cement self-etch adhesive (RCS, Panavia F 2.0, Kuraray), G3- CR + FRC + self-adhesive resin cement (SRC, Breeze, Pentral Clinical), G4- CR+ glass fiber post (GF, Exacto Post, Angelus) + RCS, G5- CR + GF + SRC. The G6 to G10 were bleached with hydrogen peroxide (HP) and restored with the same restorative procedures used for G1 to G5, respectively. After 7 days storage in artificial saliva, the specimens were submitted to the compressive strength test (N) at 0.5 mm/min cross-head speed and the failure pattern was identified as either reparable (failure showed until 2 mm below the cement-enamel junction) or irreparable (the failure showed <2 mm or more below the cement-enamel). Data were analyzed by ANOVA and Tukey test ($\alpha = 0.05$). No significant difference ($p < 0.05$) was found among G1 to G10. The results suggest that intracoronal bleaching did not significantly weaken the teeth and the failure patterns were predominately reparable for all groups. The non-metallic posts in these teeth did not improve fracture resistance.

Keywords: *dental bleaching, fracture resistance, fiber posts, composite resin*

1. Introduction

The discolouration of non-vital teeth due to endodontic treatment can occur by dissemination of blood components into the dentinal tubules, inappropriate access cavity, filling materials remaining in the pulp chamber due to incorrect cavity cleaning and inadequate use of tetracycline-containing medicaments[1,2]. Thus, the dental bleaching is frequently the treatment of choice for improving these aesthetic problems[3].

The hydrogen peroxide is widely used in the concentration 30 to 35% with photosensitive components that act as starters to initiate and catalyze the reaction when exposed to light sources[4].

The action mechanism of bleaching agents is based on a complex oxidation reaction releasing oxygen free radicals occurring chemically break down organic molecules that pigment the dentin into carbon dioxide and water released together with the nascent oxygen[5].

The use of these traditional bleaching materials, especially hydrogen peroxide, has been associated with complications such as cervical root reabsorption, increased dentine permeability, changes in the biomechanical properties of tooth related to alteration in the chemical structure of tooth occurred by demineralization and quantitative mineral loss[6,7]. However, some studies reported that there was no evident change in mechanical and morphology after bleaching treatment[3,8-10].

In addition, the endodontically treated teeth have high risk of biomechanical failure caused by elasticity of dentin decreased, lost of tooth structure from previous caries, pre-existing restorations, coronary access for endododontic treatment, suggesting the need for additional restorative

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considerations[11-13]. These changes influence the selection of restorative procedures.

Several post system techniques are available for the restoration of endodontically treated teeth when show fragile. For this, there are prefabricated metallic or non-metallic posts combined with composite resin. The metallic posts were traditionally made of stainless steel or titanium and might be visible through the structure of teeth, particularly in anterior region[15]. Also, they might have different degrees of stiffness[15]. Non-metallic posts are made either from a resin matrix reinforced with carbon, glass or quartz fibers. With the exception of carbon, the other posts showed esthetic more favorable in anterior teeth due to their light-transmitting capacity in addition to their modulus of elasticity values that are similar to that of dentine[15]. This can reduce the risk of tooth fractures and can increase their survival rates when compared to teeth restored with metallic posts[15]. These posts are also able to form a monoblock structure created by dentin, resin cement and post[16].

Therefore, the purpose of this in vitro study was to evaluate the fracture resistance and failure pattern of teeth submitted to intracoronal bleaching with 35% HP and restored with different procedures.

2. Material and Methods

The mandibular incisors were collected and stored in 0.1% thymol solution at 4 °C. Teeth were cleaned and examined under ×25 magnification using a stereomicroscopy to exclude those with caries, restorations and fracture lines or fissures. Radiographs were made to ensure that there was no internal root resorption or obstructions within the canal. The mesiodistal and buccolingual dimensions of the teeth were recorded to standardize dimensions using digital caliber (Deigimatic Caliper, Mitutoyo, Kawasaki, Japan) (Table 1). After selection and standardization, eighty teeth were used in this study.

After pulp chamber access, the root canals were prepared until 1 mm from the root length using a #10 K-file (Maillefer, Ballaigues, Switzerland). The instrumentation was performed with rotary nickel-titanium instruments (Mity, Loser, Leverkusen, Germany) according to the crown-down technique. During this process, root canals were irrigated with 2 mL of 1% sodium hypochlorite between each file, followed by final irrigation with EDTA for 5 minutes. After drying with absorbent paper points (Dentsply-Herpo, Petropolis, RJ, Brazil), the teeth were filling with gutta-percha and an epoxy resin-based canal sealer (AH Plus, Dentsply DeTrey, Konstanz).

A heated plugger was used to remove 3 mm of gutta-percha from the root canal and glass ionomer cement was used to cervical barrier at the cemento-enamel junction. Teeth were stored at 37 °C for 72 hours.

Three retentive notches were placed on the external root surface to ensure that the tooth was held firmly within the holding device during testing. The teeth were embedded in auto-polymerized acrylic resin using a metallic rectangular matrix (15 inch diameter × 15 inch height) to a level 2 mm from the cement-enamel junction. After completely cured of the acrylic resin, the specimens were randomly divided into ten groups (n = 8) according to the restorative procedures in Table 2.

Table 1. Dimensions of the teeth selected for this study.

	Length of teeth	Length of crown	Mesio-distal	Bucco-lingual
Teeth dimensions (mm)	18.0 ± 0.6	7.5 ± 0.6	4.5 ± 0.6	5.5 ± 0.5

Table 2. Groups divided according to restorative procedures.

Groups	Restorative procedure
G1	CR
G2	CR + FRC + RCS
G3	CR + FRC + SRC
G4	CR+ GF + RCS
G5	CR + GF + SRC
G6	HP + CR;
G7	HP + CR + FRC + RCS
G8	HP + CR + FRC + SRC
G9	HP + CR+ GF + RCS
G10	HP + CR + GF + SRC

The bleaching gel used was 35% hydrogen peroxide (Whiteness HP, FGM Ltda, Joinville, SC, Brazil) activated by the LED system. The gel was applied to the buccal surface and in the pulp chamber followed by a 45 seconds application of light on both surfaces. This procedure was repeated three times in each session with a 5 minutes interval between them. The teeth were stored during 7 days in artificial saliva for each session, totalizing 21 days. The non-bleaching teeth were also replaced for 21 days. The specimens were temporarily sealed with white gutta-percha (DFL, Rio de Janeiro, RJ, Brazil) and non-eugenol temporary filling material (Coltosol; Vigodent, Rio de Janeiro, RJ, Brazil) before being placed in saliva.

After dental bleaching, the post space was prepared with the drills designated for the Exacto and Everstick posts in the depth of 8 mm for groups that were restored with posts, whose reported in Table 3.

The luting materials and adhesive application protocols are described in the Table 4. The posts were luted according to manufacturers' instructions. The light cured materials were light-activated with Optilux 501 (Demetron Kerr, Orange, CA). Before each bonding procedure, the power density of the light-activated was checked with digital radiometer. The mean power density of the light-activated was 500 ± 10 mW/cm^2.

Each specimen was fixed in a device positioned at 130° from the horizontal plane. The specimens were submitted to the fracture test using a Universal Testing Machine (Instron 4301; Instron Corp, Canton, MA, USA), and compressive load was applied on specimens at a 0.5 mm/min crosshead speed on the palatal surface of the tooth (Figure 1). The specimens were loaded to fracture and force at failure (N) was recorded. The failure pattern of each specimen was categorized as reparable when the failure showed until 2 mm below the cement-enamel junction or catastrophic

Table 3. Non-metallic posts used in this study.

Post	Manufacturer	Post type and design	Post composition	Batch number
Exacto post	Angelus, Londrina, Brazil	Opaque Cervical diameter, 1.8 mm Middle diameter, 1.8 mm Apical diameter, 1.1 mm	Glass fiber: 87% volume Epoxy resin: 13% volume Internal filament: stainless steel	2070814-P3-036
Everstick post	Stickteck Ltd., Turku, Finland	Individually formed Electrical glass fiber mean diameter, 1.5 mm	Semi-interpenetrating polymer network of Polymethylmethacrylate, Mw 220.000 and 2.2-bis [4-(2-hydroxy-3-methacryloxypropoxy) phenyl] propane)	8217

Table 4. Luting material and adhesive application protocols.

Product name (manufacter)	Composition	Dentin pre-treatment	Luting agent mixing	Batch number
Breeze self-adhesive resin cement (PENTRON Clinical Technologies, Wallingford, USA)	BISGMA, UDMA, TEGDMA, HEMA, & 4-MET resins, silane-treated, bariumborosilicate glasses*, silica with initiators, stabilizers and UV absorber, organic and/or inorganic pigments, opacifiers[a]	No pre-treatment	Dispense the cement, light cure for 1 second from each side after removal excess cement.	161489
Panavia F 2.0 Dual Cure Resin Cement (Kuraray, Osaka, Japan)	Primer A: HEMA, 10-MDP, 5-NMSA, water, accelerator[a]	Mix one drop of each ED Primer liquids A and B for 5 seconds, apply undisturbed for 30 seconds, air-dry gently	Mix paste A and B for 20 seconds, light cure for 20 seconds from each side after removal excess cement, apply oxyguard for 3 minutes	00243B
	Primer B: 5-NMSA, water, sodium benzene[a]			00121B
	Paste A: 10-MDP, 5-NMSA, silica, dimethacrylate monomer, photo-initiator, accelerator[a]			00265B
	Paste B: barium glass, sodium fluoride, dimethacrylate monomer, BPO[a]			00043B
	Oxiguard II: glycerol, polyethyleneglycol, initiators, accelerators, dyes, others[a]			00564B

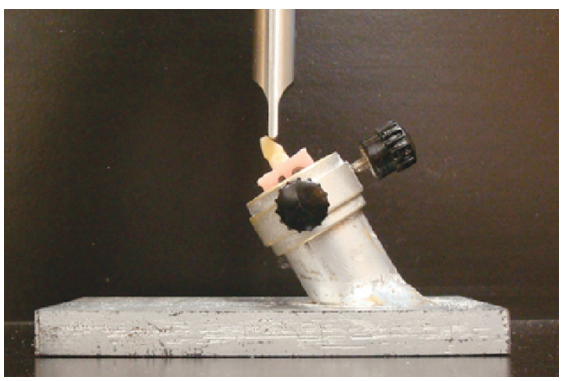

Figure 1. The specimen was fixed in a device positioned at 130° from the horizontal plane and an increasing load was applied on the palatal surface of the tooth with a rectangular round-tipped metal point.

(irreparable) when the failure showed <2 mm or more below the cement-enamel junction (Figure 2).

3. Results

Statistical analysis of the data was carried out using Prism Program (release 5.0, GraphPad, San Diego, CA). One-way analysis of variance (ANOVA) followed by Tukey's test. The mean and standard deviation of the strength required to fracture the teeth in each group are reported in Table 5. Failure pattern of each specimen submitted to fracture are reported in Table 6.

4. Discussion

Intracoronal bleaching is an established, simple and conservative method used on non-vital teeth[17]. Some studies have evaluated the effects of peroxide-containing products on the physical and chemical properties of tooth. However, researches in this area have been controversial[6-10]. Pobbe et al.[18] evaluated the fracture resistance of endodontically treated teeth submitted to dental bleaching. The study showed decrease of fracture resistance after 2 sessions of bleaching with 38% hydrogen peroxide activated by LED-laser system. In this study, when comparing the bleaching groups with non-bleaching groups after 3 weeks, there were no statistically significant differences among themselves.

Azevedo et al.[19] studied fracture resistance of teeth submitted to internal bleaching and restored with different procedures, and concluded that the bleached teeth can be restored with composite resin alone and the use of posts in these teeth did not increase their resistance.

(a) (b)

Figure 2. The failure pattern of each specimen was categorized as reparable when the failure showed until 2 mm below the cement-enamel junction (a) or irreparable when the failure showed <2 mm or more below the cement-enamel junction (b).

Table 5. Means and standard deviation (SD) of fracture resistance (N) for all groups.

Group	Means	SD
G1	263.8a	45.42
G2	262.3a	27.43
G3	262.4a	51.33
G4	266.6a	30.25
G5	258.4a	59.12
G6	273.1a	49.66
G7	296.1a	50.01
G8	298.0a	54.20
G9	264.7a	79.16
G10	256.2a	55.95

Means followed by the same lowercase letter at the collum are statistically similar, Tukey's Test ($p > 0.05$).

Table 6. Failure pattern of each specimen submitted to fracture.

Group	Reparable	Catastrophic
G1	5	3
G2	6	2
G3	5	3
G4	7	1
G5	4	4
G6	5	3
G7	7	1
G8	6	2
G9	5	3
G10	6	2

Means followed by the same lowercase letter at the collum are statistically similar, Tukey's Test ($p > 0.05$).

The results showed a standard deviation within the normal range. Although the teeth have been selected previously, which are reported in Table 1, the human teeth have different levels of mineralization that occurs deposition of tertiary reactionary dentin in their lifetime due to the stress absorbed by the tooth[20]. In addition, the fracture resistance of the endodontically-treated teeth are dependent on the amount of retained residual dentin[21,22].

A review study[23] investigated the impact of bleaching procedures on enamel microhardness (in vitro and in situ studies). The majority of bleaching applications evaluating post-treatment enamel surface hardness showed recovery of hardness to baseline values. The most studies using human and artificial saliva in the post-treatment phase did not show difference of hardness as compared to baseline values, thus indicating complete recovery of enamel surface hardness[23].

The absence of decreasing fracture resistance may be explained by modulating remineralization and demineralization promoted by saliva, which can keep the integrity of tooth enamel[24]. The main factors controlling the stability of enamel hydroxyapatite are the active concentrations of free calcium, phosphate, and fluoride in solution and the salivary pH[24].

Moreover, the controversial outcomes of dental bleaching studies can be due to diversity in the experimental setups, making a comparison among results very difficult[9].

Working with hypothesis based on the controversial studies about morphological change of the enamel and/or dentin surfaces, this study chose to analyze the application of different restorative procedures. The use of non-metallic posts luted with different resin cements had no significant difference for the values of fracture resistance, because the modulus of elasticity in these posts is similar to human dentin (around 25 GPa in dentin[14])[15,16]. Moreover, the aim of posts is improve the retention of the filling material in the remaining tooth structure[25].

The load was applied on the palatal surface of the tooth with a rectangular round-tipped metal point (Figure 1) and after the fracture was analyzed. A reparable fracture pattern was observed for most teeth restored with non-metallic post

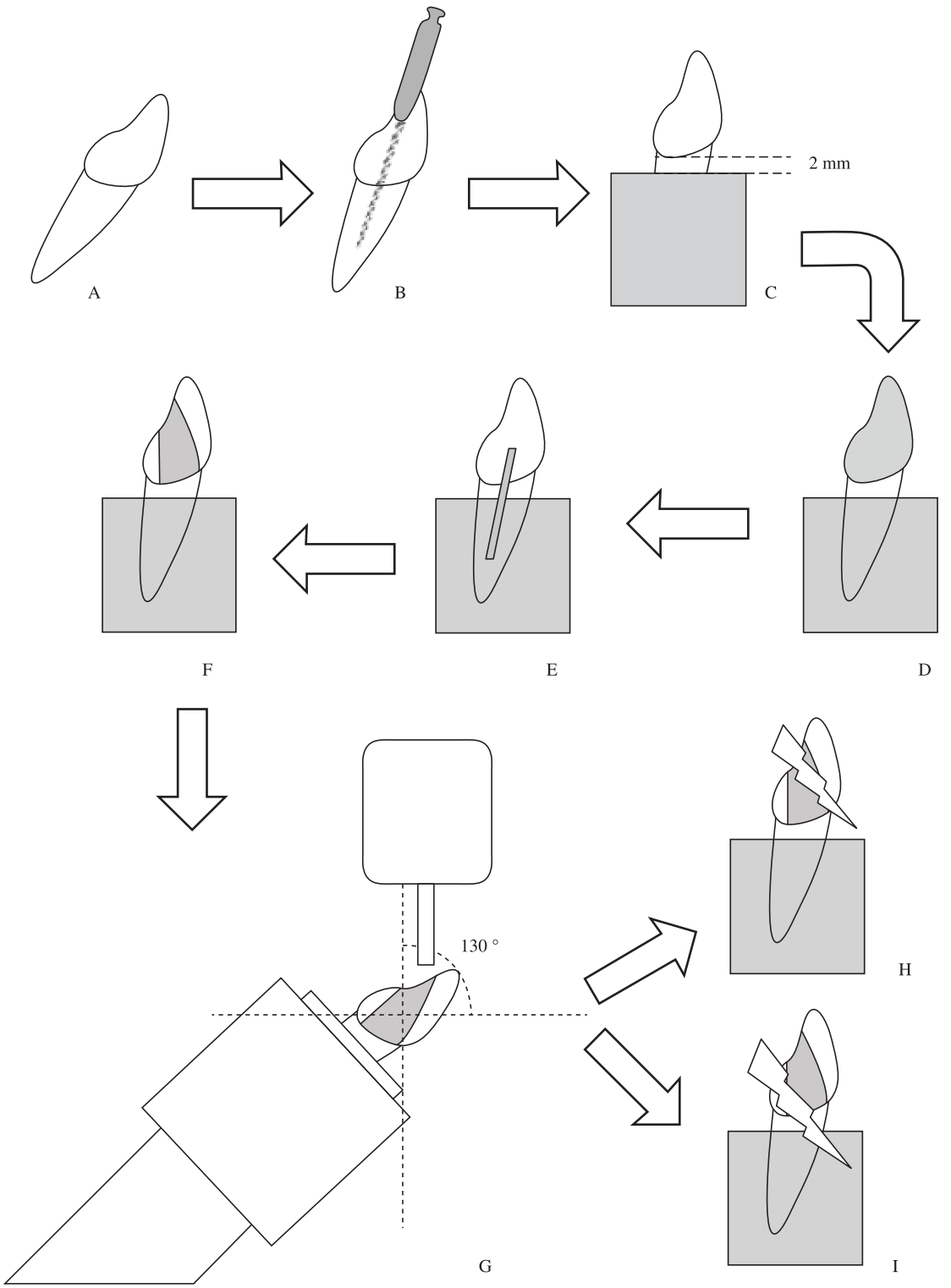

Figure 3. a) Mandibular incisor teeth selected for this study; b) the teeth were endodontically treated; c) the teeth were embedded in auto-polymerized acrylic resin using a metallic rectangular matrix to a level 2 mm from the cement-enamel junction; d) half teeth were bleaching with 35% hidrogen peroxide; e) half teeth were inserted non-metallic posts cemented with resin cement; f) the teeth were restored with composite resin; g) Each specimen was fixed in a device positioned at 130° from the horizontal plane. The specimens were submitted to the fracture test using a Universal Testing Machine and compressive load was applied on specimens at a 0.5 mm/min crosshead speed on the palatal surface of the tooth. h) Reparable fracture is when failure showed until 2 mm below the cement-enamel junction; i) irreparable fracture is when the failure showed <2 mm or more below the cement-enamel junction.

or using only composite resin (Figure 3). It suggests that they had an adequate distribution of the forces.

5. Conclusion

Dental bleaching was not able to decrease the fracture resistance of the tooth. Furthermore, the restoration of endodontically treated teeth associated with the use of non-metallic posts had similar fracture resistance and failure pattern as those restored only with composite resin.

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