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Original Article

The effect of intraorifice barriers (TheraCal LC, Lime-Lite and Ionoseal) on the fracture resistance and failure patterns of endodontically treated teeth submitted to intracoronal bleaching

Atiyeh Feiz[1], Masoomeh Shams[1], Hessamoddin Faghihian[2], Parwaneh Yousefi[2]

[1]Dental Materials Research Center, Department of Operative Dentistry, Dental Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran, [2]Department of Operative Dentistry, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran

ABSTRACT

Background: The aim of the study was to compare the root reinforcement potential of different light cured intraorifice barriers (TheraCal, lime-lite, Ionoseal and resin-modified glass-ionomer [RMGI] [Fuji II LC]) with or without bonding agent placed in the orifice of endodontically treated and bleached teeth.

Materials and Methods: In this experimental *in vitro* study, single-rooted bovine teeth were instrumented and obturated with gutta-percha. Except the control group, in other specimens, gutta-percha was removed 3 mm under cementoenamel junction. Then, the specimens were divided into seven groups according to the bases was applied: TheraCal LC, TheraCal LC with bonding agent, Lime-Lite, Lime-Lite with bonding agent, Ionoseal, Ionoseal with bonding agent, and RMGI (Fuji II LC). After internal bleaching, the teeth were decoronated. Then, all the groups were subjected to fracture resistance testing using Universal Testing Machine. For evaluating fracture resistance, analysis of variance and Tukey's test were used and for comparing the mode of fracture fisher test was applied in SPSS software. The significance was determined at ($\alpha = 0.05$) confidence interval.

Results: The group of TheraCal LC with bonding agent showed better fracture resistance as compared to the control group ($P = 0.004$). Although there was no statistically significant difference in the pairwise comparison between the other groups.

Conclusion: TheraCal LC with bonding agent can be used as intraorifice barriers with good fracture resistance in endodontically treated and bleached teeth.

Key Words: Fracture resistance, intracoronal bleaching, intraorifice barrier

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Address for correspondence:
Dr. Atiyeh Feiz,
Department of Operative Dentistry, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran.
E-mail: atiyehfeiz@gmail.com

INTRODUCTION

Many studies have reported the adverse effects of bleaching agents when applied to dental structures. These include external cervical resorption, cervical caries, increase dentin permeability, reduction in microhardness of dentin and enamel, reduction in bond strength, and increased microleakage in composite resin restorations performed after dental bleaching.[1] These effects could be related to the presence of residual hydrogen peroxide in the interprismatic spaces as well as in the dentinal matrix and tubules. Bleaching agents also can cause chemical

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alterations in the hard dental tissues, changing the ratio of organic-to-inorganic composition, and increasing the tooth's solubility, which subsequently reduces the bond strength of resin-based composite restorations.[1]

There is great concern about the adverse effects of bleaching agents on teeth.[2] Tooth crown fracture has been reported after intracoronal bleaching, which is most probably due to removing a large proportion of dentin structure. Besides, intracoronal bleaching with 30% hydrogen peroxide decreases enamel and dentin microhardness, compromising dentin's mechanical properties, which might affect the bleached tooth's fracture resistance.[3,4] Previous clinical studies have shown that 11%–13% of extracted teeth with previous endodontic treatment have been associated with vertical root fracture (VRF). These fractures usually occur after root canal therapy due to tooth structure loss, using irrigation solutions and medications, and excessive flaring of the root canals.[5] Many studies have evaluated strategies for intracanal reinforcement of teeth, including the use of root canal filling materials with low elastic modulus or root canal dentin bonding agents or both; however, currently, the reinforcing potential of the techniques and materials is not satisfactory.[6] Intraorifice barriers, too, can be a proper choice to decrease the incidence of root fractures after root canal treatment.[5] Studies evaluating the potential of intraorifice barriers have shown that root canal-treated teeth with intraorifice barriers exhibited greater resistance to fracture than samples without these barriers, indicating that roots' fracture resistance was significantly affected by the type of these barriers.[5-9]

The studies mentioned above have evaluated the effect of intraorifice barriers on the fracture resistance of root canal-treated teeth. However, a few studies have evaluated the effect of intraorifice barriers on the fracture resistance of root canal-treated and bleached teeth. As mentioned above, due to the additional weakening of the tooth structure in root canal-treated teeth with intracoronal bleaching, it is of utmost importance to strengthen the remaining structure of these teeth. Since it is necessary to place a reliable intraorifice barrier to prevent cervical resorption of the root during intracoronal bleaching of root canal-treated teeth, the use of intraorifice barriers might be a proper choice to strengthen the root canal-treated teeth undergoing intracoronal bleaching.[4,10]

Since novel light-cured bases, including Lime-Lite, Ionoseal, and TheraCal, have been introduced in recent years, which are very easy to use; the present study aimed to evaluate and compare the reinforcing potential of these three agents with or without a bonding agent as an intraorifice barrier in root canal-treated teeth having undergone a bleaching procedure. The null hypothesis was that the intraorifice barrier increases the fracture resistance of endodontically treated teeth having undergone a bleaching procedure.

MATERIALS AND METHODS

In the present *in vitro* study, 80 bovine lateral incisor teeth with no cracks, defects, and caries were selected and stored in normal saline solution. The soft tissues on the root surfaces were removed with a scalpel blade (Morris, China). Access cavities were prepared with #842 fissure burs and #801 round burs (Jota, Switzerland) in a high-speed handpiece. The root canals were prepared using the crown-down technique using K-files (Mani, Japan). The root canals were irrigated with 2 mL of 1% NaOCl (Pakshoma, Iran) between files. Apical enlargement continued up to file #80. The root canals were then obturated with gutta-percha (Meta Biomed, Korea) and AH26 sealer (Dentsply, Germany) using the lateral compaction technique. The access cavity was covered with Cavit (Golchai, Iran). The teeth were incubated at 100% relative humidity at 37°C for 24 h. In all groups, gutta-percha was removed with a hot plugger up to 3 mm below the cementoenamel junction (CEJ), except for group 8 (the control group), in which gutta-percha was removed up to 1 mm below the CEJ. The smear layer was removed with 17% EDTA. The teeth were assigned to eight groups (n = 10) so that the mean mesiodistal and buccolingual dimensions of the cervical area of teeth, measured with a digital vernier (4–100, 24, Guilin Guanglu, China) were similar in all the groups. The groups were designated as follows: (1) TheraCal; (2) TheraCal with a bonding agent; (3) Lime-Lite; (4) Lime-Lite with a bonding agent; (5) Ionoseal; (6) Ionoseal with a bonding agent; (7) Fuji II LC, and (8) Control.

In Groups 2, 4, and 6, the CLEARFIL™ SE Bond bonding agent, and in Group 7, polyacrylic acid conditioner (GC Fuji Plus Conditioner, Japan) was applied according to the manufacturer's instructions. In all the groups, intraorifice barriers [Table 1] were

Table 1: The compositions of the materials used

Material	Material type	Manufacturer	Compositions
Ionoseal	Light-cured composite-glass-ionomer	Voko, Cuxhaven, Germany	SiO2, CaF2, AIF3, Na3AIF6 A1203, silicate powder, Bis-GMA HEMA, TEDMA
TheraCal LC	Light-cured resin-modified calcium silicate	Bisco, Schamburg, IL, USA	Portland cement (calcium silicates) fumed silica, Bis-GMA, polyglycol dimethacrylate
Fuji II LC	Light-cured RMGI	GC Corporation, Tokyo, Japan	Powder: Flouroaluminosilicate glass Liquid: Copolymer of acrylic acid and maleic acid, HEMA, water, camphorquinone, activator
Lime-Lite	Light-cured resin-modified calcium hydroxide	Pulpdent Corporation, Watertown, USA	Acrylate resin, hydroxyapatite calcium hydroxide, calcium phosphate tribasic Photo-chemistry glass filler
Clearfil™ SE bond	Two-step self-etch light-cured bonding agent	Kuraray, Japan	Etching/primer: 2-hydroxyethyl methacrylate 20%-40%, 10-methacryloyloxydecyl dihydrogen phosphate, hydrophilic aliphatic dimethacrylate, dl-Camphorquinone accelerators, water, dyes Bond: Bisphenol A diglycidylmethacrylate 25%-45%, 2hydroxyethyl methacrylate 20%-40%, 10-methacryloyloxydecyl dihydrogen phosphate, hydrophobic aliphatic methacrylate, colloidal silica, dl-camphorquinone, initiators, accelerators

RMGI: Resin-modified glass-ionomer

placed according to the manufacturer's instructions, measuring 2 mm in thickness, up to 1 mm below the CEJ, by following the CEJ curvature, except for the control group, followed by light-curing for 20 s with a Demetron LC light-curing unit (SDS, Kerr, USA) at a light intensity of 1000 mW/cm^2. The samples were incubated at 100% relative humidity at 27°C for 24 h (Behaded, Iran).

In each group, a piece of cotton impregnated with 35% H_2O_2 was placed in the access cavity, and the teeth were heat treated with a 1000-W light for 2 min, which was repeated twice by placing a new piece of cotton impregnated with 35% H_2O_2. Finally, the access cavity was irrigated with distilled water and dried. The tooth crowns were removed with a cutting device (Dentarapid, Krupp Dental, Germany) at CEJ. The root surfaces were covered up to 3 mm below the CEJ with a 0.4 mm thick layer of green casting wax (Sinooth Casting Wax, Iran).

The teeth were then mounted in plastic cylinders with a self-cured acrylic resin (Acropars, Iran) along the tooth long axis with 3 mm of the root exposed. After polymerization of the acrylic resin, the teeth were retrieved from the cylinders, and the wax was removed from the root surfaces and the acrylic cylinders. The impression material wash (Speedex Light Body and Universal Activator, Switzerland) was placed in the cylinders, and the tooth was placed in the cylinder. Excess material was removed with a scalpel blade (Morris, China).

The fracture resistance test was carried out with a Universal Testing Machine (K − 21046, Walter + bai, Switzerland). A compressive force was applied at a crosshead speed of 0.5 mm/min along the tooth long axis to the root canal orifice with a round-head rod until fracture. The fracture moment was indicated by a sudden decrease in force, as determined by the machine. Fracture modes were determined under a stereomicroscope (SMP − 200, HP, USA) at ×74.

The samples were categorized into two groups based on the fracture pattern:

Type I: Restorable fractures; those in the cervical third of the root

Type II: Nonrestorable fractures; those in the middle or the apical third of the root.

Data were analyzed with SPSS software (SPSS v. 23, SPSS Corp., Chicago IL, USA). According to the normality of data, one-way analysis of variance was used to compare data related to the groups' fracture resistance followed by *post hoc* Tukey's tests. Fisher's exact test was used to analyze fracture types ($\alpha = 0.05$).

RESULTS

Variance analysis on the data log showed significant differences between the eight study groups ($P = 0.006$) [Table 2]. *Post hoc* Tukey's tests showed that the mean fracture resistance in the TheraCal bonded group was significantly higher than in the control group ($P = 0.004$), with no significant difference between the other groups. Fisher's exact test showed no significant differences in the frequencies of fracture types between the eight study groups [Table 3].

DISCUSSION

Endodontically treated teeth have been reported to present a higher risk of biomechanical failure than vital teeth, suggesting the need for additional restorative considerations. The dentin of endodontically treated teeth undergoes changes in both its physiologic characteristics, such as a decrease in the immature collagen levels, and its physical properties, whereby dehydration causes a decrease in the modulus of elasticity. These changes accompanying root canal therapy influence the approach and selection of restorative procedures. In the current study, before fracture testing and combination bleaching, the study specimens were subjected to endodontic treatment. Biochemical and biomechanical changes in dentin following endodontic treatment and tooth structure lost during access opening must definitely have influenced the fracture resistance of the specimens.[1]

Previous clinical studies have shown that the prevalence of VRF s in endodontically treated teeth is approximately 11%–13%.[11] Since root canal treatment does not lead to a significant change in biomechanical properties of teeth, loss of the tooth structure due to dental caries, trauma, restorative procedures, root canal treatment, use of intracanal irrigation solutions and medications, and excessive enlargement of the root canals lead to tooth susceptibility to fracture. Besides, tooth crown fracture has been reported after intracoronal bleaching.[12] Intracoronal bleaching with 30% hydrogen peroxide decreases enamel and dentin microhardness and slightly compromises dentin's mechanical properties.[13,14]

Table 2: Fracture resistance (N) in the eight study groups

Groups	Mean	SD	Minimum	Maximum
Control	458.45[a]	250.44	187.80	905.24
Fuji II LC	648.62[a]	236.62	357.12	947.60
Ionoseal	589.55[a]	363.26	320.00	1517.12
Ionoseal with bonding agent	754.72[a]	376.16	352.70	1440.20
Lime-Lite	542.72[a]	222.12	300.00	912.98
Lime-Lite with bonding agent	514.09[a]	217.49	246.98	942.24
TheraCal	700.62[a]	250.15	314.26	1061.44
TheraCal with bonding agent	857.24[b]	206.602	600.00	1183.82
Total	632.49	289.62	187.80	1517.12

[a,b]Different superscripts indicate statistically significant differences. SD: Standard deviation

Table 3: The frequencies of fracture patterns in the eight study groups

Groups	Fracture mode	
	Restorable, *n* (%)	Nonrestorable, *n* (%)
Control	6 (60.0)	4 (40.0)
Fuji II LC	5 (50.0)	5 (50.0)
Ionoseal	7 (70.0)	3 (30.0)
Ionoseal with bonding agent	5 (50.0)	5 (50.0)
Lime-Lite	8 (80.0)	2 (20.0)
Lime-Lite with bonding agent	7 (70.0)	3 (30.0)
TheraCal	4 (40.0)	6 (60.0)
TheraCal with bonding agent	5 (50.0)	5 (50.0)
Total	48 (60.0)	32 (40.0)

Different bleaching agents or whitening techniques can adversely affect the fracture resistance of teeth, likely owing to the changes in dental structure, such as those related to porosity, demineralization, decreased adhesion of restorative materials to dentin, increased dentin permeability, reduced dentin microhardness, and decreased dentin diametral tensile strength.[15]

According to Kawamoto and Tsujimoto, the hydroxyl radical (OH) resulting from hydrogen peroxide degradation is responsible for tooth whitening, and acts on intertubular and peritubular dentin, destroying its organic portion, increasing permeability, and decreasing its hardness and elasticity modulus, which can be intensified with a greater exposure time of the tooth to the bleaching agent.[16]

Hydrogen peroxide is capable of producing OHs in the presence of iron salts, which is responsible for bleaching effects. Due to the high oxidation potential, OHs break down the polypeptide chains of peritubular and intertubular dentin; decompose the connective tissue composition, especially collagen and hyaluronic acid; and absorb dentin's organic content. These ultrastructural changes increase dentin permeability and reduce its hardness and elasticity. The acidic pH measured for hydrogen peroxide is lower than the critical peak of the enamel. A pH level between 4.5 and 5.5 can demineralize enamel hard tissue. However, demineralization can also be associated with low concentrations of calcium and phosphate ions and a high concentration of sodium and chloride ions in the bleaching agent, which can be a factor in reducing the saturation of hydroxyapatite.[17,18]

On the contrary, dental changes due to bleaching were time-dependent, and studies have shown that mechanical properties of teeth reduced 2 months after bleaching.[18]

It is also noteworthy to mention that some authors have reported that the heat applied to activate the bleaching agent or even produced by chemical reactions during this clinical procedure may cause reversible or even irreversible and deleterious effects on dental and periodontal tissues. However, some studies have shown that this negative effect may be offset by the thermal insulating capability of dentin, which reduces the amount of heat reaching the pulp chamber significantly.[15,19,20]

The effect of intracoronary bleaching along with the loss of a large amount of tooth structure in endodontically treated teeth may cause the teeth to fracture during function.[21]

It has been suggested that bonded restorative materials should be used to reinforce the weakened tooth structure.[22] Bonded obturation materials might increase the fracture resistance of root canal-treated teeth; however, the currently available obturation systems cannot achieve this aim.[6] Furthermore, intraorifice barriers can be a proper choice to decrease root fractures after root canal treatment.[5] Furthermore, the adhesive system used to bond intraorifice barriers has the ability to moisten and infiltrate into the dentin which creates micromechanical retention, promoting stress distribution through the dentin, and reducing the chances of fracture.[15,17]

Endodontically treated teeth have been reported to present a higher risk of biomechanical failure than vital teeth, suggesting the need for additional restorative considerations. The dentin of endodontically treated teeth undergoes changes in both its physiologic characteristics, such as a decrease in the immature collagen levels and its physical properties, whereby dehydration causes a decrease in the modulus of elasticity. These changes accompanying root canal therapy influence the approach and selection of restorative procedures. In the current study, before fracture testing and combination bleaching, the study specimens were subjected to endodontic treatment. Biochemical and biomechanical changes in dentin following endodontic treatment and tooth structure lost during access opening must definitely have influenced the fracture resistance of the specimens.[1]

The present study aimed to evaluate the fracture resistance of endodontically treated teeth that had undergone intracoronal bleaching. A reliable intraorifice barrier is necessary during intracoronal bleaching to prevent cervical resorption of the root as a general rule. Therefore, the root's fracture resistance was evaluated in the present study after placing Lime-Lite, Ionoseal, light-cured TheraCal with or without a bonding agent, and Fuji II LC as intraorifice barriers compared to a control group with no intraorifice barrier. The results showed that of all the study groups, the roots' fracture resistance was significantly higher than in the control group but only in the light-cured TheraCal group with a bonding agent this increase was significant. Therefore, the null hypothesis was confirmed only for TheraCal in association with a bonding agent. In other materials, the null hypothesis was rejected.

In this study, bovine teeth were used. The reason for the choice of bovine teeth was due to its ultimate tensile strength and modulus of dentin elasticity are similar to human teeth.[23]

TheraCal is a resin-modified light-cured calcium silicate cement. Compared to mineral trioxide aggregate (MTA) and conventional calcium silicate cement, the resin-modified version has some advantages, including rapid photopolymerization, prevention of material dissolution, and superior mechanical properties.[24] It has been reported that TheraCal has higher compressive and flexural strengths than other calcium silicate cement, including biodentine and MTA, with good bond strength in the face of pH changes.[25,26] No study has evaluated the root-reinforcing potential of TheraCal as an intraorifice barrier. However, other calcium silicate cement, such as MTA and biodentine, have been evaluated as intraorifice barriers in endodontically treated teeth. Studies by Yasa *et al*. and Nagas *et al*. did not show that MTA was able to increase fracture resistance; however, biodentine increased the fracture resistance of endodontically treated teeth, which is different from the results of a study by Gupta *et al*., who showed that MTA as an intraorifice barrier in endodontically treated teeth increased the fracture resistance of teeth significantly. However, the mean fracture resistance in the MTA group was significantly less than that in other study groups.[11,21,27] Only TheraCal, in association with a bonding agent, significantly increased fracture resistance in the present study. Therefore, the Clearfil™ SE Bond, a two-step self-etch bonding system, can increase fracture resistance due to its ability to moisten and infiltrate into the dentin which creates micromechanical retention and promotes stress distribution through the dentin, and reducing the chances of fracture.[15] Furthermore, maybe the release of calcium silicate from TheraCal during bleaching process and diffusion of them inside dentin can be an additive factor in strengthening the tooth structure.

In the present study, Lime-Lite cavity liner, a light-cured resin-modified calcium hydroxide product, and Ionoseal, a light-cured composite-glass-ionomer, were used as intraorifice barriers. The results showed that these materials with and without a bonding agent did not increase fracture resistance significantly. Previous studies have not evaluated the effects of these materials as intraorifice barriers on reinforcing the roots. Fuji II LC is a resin-modified glass-ionomer (RMGI) whose methacrylate content is similar to composite resin.[8] Several studies have confirmed the effect of RMGI as a cervical barrier in preventing microleakage during internal bleaching.[27] In the present study, although Fuji II LC increased fracture resistance to a great extent (approximately 200 N) compared to the control group, the difference was not significant statistically, which is different from previous studies. Aboobaker *et al*. and Nagas *et al*. reported in two separate *in vitro* studies that placing an RMGI base significantly increased fracture resistance in premolar teeth.[14,21] Gupta *et al*. evaluated the effects of four nanohybrid composite resin, fiber-reinforced composite resin, RMGI, and MTA as intraorifice barriers on the fracture resistance of root canal-treated premolar teeth and reported that the fracture resistance increased significantly in all the groups compared to the control group.[11] The differences between the results of previous studies and the present study might be attributed to differences in samples, including bovine teeth and intracoronal bleaching with 35% hydrogen peroxide. In contrast, the previous studies mentioned above have used human premolar teeth that had undergone endodontic treatment.

In this study, bovine teeth were used and several intraorifice barriers and bonding materials were applied. It is suggested to use human teeth and more variety of materials in future studies to extent it to clinical conditions.

CONCLUSION

Under the limitations of the present study, the use of TheraCal in association with a bonding agent as an intraorifice barrier before intracoronal bleaching of root canal-treated teeth increased fracture resistance. Ionoseal, Lime-Lite, and Fuji II LC did not significantly increase fracture resistance. There was no significant difference between patterns of fracture among all groups. Therefore, placing intraorifice barriers did not change the fracture patterns of these teeth.

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Department of Operative Dentistry, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran.

Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

REFERENCES

1. Antony A, Pillai R, Varghese N, Sujathan UN, Afzal A, George S. Fracture resistance of teeth undergoing postendodontic bleaching: Comparison of four treatment modalities – An *in vitro* study. Endodontology 2019;31:150.
2. Plotino G, Buono L, Grande NM, Pameijer CH, Somma F. Nonvital tooth bleaching: A review of the literature and clinical procedures. J Endod 2008;34:394-407.
3. Hattab FN, Qudeimat MA, al-Rimawi HS. Dental discoloration: An overview. J Esthet Dent 1999;11:291-310.
4. Dahl JE, Pallesen U. Tooth bleaching – A critical review of the biological aspects. Crit Rev Oral Biol Med 2003;14:292-304.
5. Zimmerli B, Jeger F, Lussi A. Bleaching of nonvital teeth. A clinically relevant literature review. Schweiz Monatsschr Zahnmed 2010;120:306-20.
6. Tredwin CJ, Naik S, Lewis NJ, Scully C. Hydrogen peroxide tooth-whitening (bleaching) products: Review of adverse effects and safety issues. Br Dent J 2006;200:371-6.
7. Bicer CO, Oz FD, Attar N. Effects of two different bleaching agents on surface roughness and microhardness of different novel nano-restorative materials. European J Gen Dent 2017;6:86.
8. Pobbe Pde O, Viapiana R, Souza-Gabriel AE, Marchesan MA, Sousa-Neto MD, Silva-Sousa YT, *et al.* Coronal resistance to fracture of endodontically treated teeth submitted to light-activated bleaching. J Dent 2008;36:935-9.
9. Joiner A. The bleaching of teeth: A review of the literature. J Dent 2006;34:412-9.
10. Azevedo RA, Silva-Sousa YT, Souza-Gabriel AE, Messias DC, Alfredo E, Silva RG. Fracture resistance of teeth subjected to internal bleaching and restored with different procedures. Braz Dent J 2011;22:117-21.
11. Gupta A, Arora V, Jha P, Nikhil V, Bansal P. An *in vitro* comparative evaluation of different intraorifice barriers on the fracture resistance of endodontically treated roots obturated with gutta-percha. J Conserv Dent 2016;19:111-5.
12. Canoglu E, Gulsahi K, Sahin C, Altundasar E, Cehreli ZC. Effect of bleaching agents on sealing properties of different intraorifice barriers and root filling materials. Med Oral Patol Oral Cir Bucal 2012;17:e710-5.

13. Nagas E, Uyanik O, Altundasar E, Durmaz V, Cehreli ZC, Vallittu PK, *et al.* Effect of different intraorifice barriers on the fracture resistance of roots obturated with Resilon or gutta-percha. J Endod 2010;36:1061-3.
14. Aboobaker S, Nair BG, Gopal R, Jituri S, Veetil FR. Effect of intra-orifice barriers on the fracture resistance of endodontically treated teeth – an *ex-vivo* study. J Clin Diagn Res 2015;9:C17-20.
15. Roberto AR, Sousa-Neto MD, Viapiana R, Giovani AR, Souza Filho CB, Paulino SM, *et al.* Effect of different restorative procedures on the fracture resistance of teeth submitted to internal bleaching. Braz Oral Res 2012;26:77-82.
16. Kawamoto K, Tsujimoto Y. Effects of the hydroxyl radical and hydrogen peroxide on tooth bleaching. J Endod 2004;30:45-50.
17. Magalhães JG, Marimoto AR, Torres CR, Pagani C, Teixeira SC, Barcellos DC. Microhardness change of enamel due to bleaching with in-office bleaching gels of different acidity. Acta Odontol Scand 2012;70:122-6.
18. Oskoee SS, Bahari M, Daneshpooy M, Ajami AA, Rahbar M. Effect of different intraorifice barriers and bleaching agents on the fracture resistance of endodontically treated anterior teeth. J Endod 2018;44:1731-5.
19. Bonfante G, Kaizer OB, Pegoraro LF, do Valle AL. Fracture resistance and failure pattern of teeth submitted to internal bleaching with 37% carbamide peroxide, with application of different restorative procedures. J Appl Oral Sci 2006;14:247-52.
20. Hansen EK, Asmussen E. *In vivo* fractures of endodontically treated posterior teeth restored with enamel-bonded resin. Endod Dent Traumatol 1990;6:218-25.
21. Nagas E, Cehreli ZC, Uyanik O, Vallittu PK, Lassila LV. Reinforcing Effect of glass fiber-incorporated ProRoot MTA and Biodentine as intraorifice barriers. J Endod 2016;42:1673-6.
22. Soares CJ, Pizi EC, Fonseca RB, Martins LR. Influence of root embedment material and periodontal ligament simulation on fracture resistance tests. Braz Oral Res 2005;19:11-6.
23. Leonardo Rde T, Kuga MC, Guiotti FA, Andolfatto C, Faria-Júnior NB, Campos EA, *et al.* Fracture resistance of teeth submitted to several internal bleaching protocols. J Contemp Dent Pract 2014;15:186-9.
24. Bahuguna N. Cervical root resorption and non vital bleaching. Endodontology 2013;25:106-11.
25. Fadag A, Negm M, Samran A, Samran A, Ahmed G, Alqerban A, *et al.* Fracture resistance of endodontically treated anterior teeth restored with different post systems: An *in vitro* study. Eur Endod J 2018;3:174-8.
26. Hu YH, Pang LC, Hsu CC, Lau YH. Fracture resistance of endodontically treated anterior teeth restored with four post-and-core systems. Quintessence Int 2003;34:349-53.
27. Yasa E, Arslan H, Yasa B, Akcay M, Alsancak M, Hatirli H. The force required to fracture endodontically roots restored with various materials as intra-orifice barriers. Niger J Clin Pract 2017;20:1237-41.