Original Article

A comparative evaluation of fracture resistance of endodontically treated teeth using four different intraorifice barriers: An in vitro study

Parul Chauhan, Ashima Garg, Rakesh Mittal, Hemashi Kumar

Department of Conservative Dentistry and Endodontics, Sudha Rustagi College of Dental Sciences and Research, Faridabad, Haryana, India

Abstract

Aim: The aim of this study is to evaluate and compare the fracture resistance of endodontically treated teeth using four intraorifice barriers.

Materials and Methods: Fifty extracted single-rooted mandibular premolars were selected, decoronated, and prepared with rotary Protaper universal system and obturated with gutta-percha and AH Plus sealer. Samples were divided into five groups (n = 10) on the basis of intraorifice barrier material used. Group 1: Biodentine, Group 2: Conventional glass ionomer cement (GIC), Group 3: Resin-modified glass ionomer cement (RMGIC), Group 4: Nanohybrid composite, Group 5: No barrier (control). Except for control specimens, coronal 3-mm gutta-percha was removed and filled with different intraorifice barrier materials in respective groups. Fracture resistance of specimens was tested using universal testing machine.

Statistical Analysis Used: One-way analysis of variance test and Post hoc Tukey’s test.

Results: Mean fracture resistance of all experimental groups (with intraorifice barriers placed) were higher than control group (no intraorifice barrier placed). Biodentine showed the highest mean fracture resistance while RMGIC showed the least and the difference between their mean fracture resistance was statistically significant. There was no statistically significant difference among other experimental groups.

Conclusion: Placement of intraorifice barriers in endodontically treated teeth can significantly increase fracture resistance and this increase in fracture resistance is material dependent.

Keywords: Biodentine; conventional glass ionomer cement; intraorifice barrier; nanohybrid composite; resin-modified glass ionomer cement

INTRODUCTION

Endodontically treated teeth are more prone to fracture than vital teeth. Many iatrogenic and noniatrogenic factors have been found to be responsible for compromised resistance to fracture in endodontically treated teeth, some of which are wide canal taper, occlusal stresses, dehydration of dentinal tubules, and reduced mechanical properties of such teeth, contributing to fatigue induced root fractures.[1] During instrumentation, numerous momentary contacts between instruments and canal walls create stress concentrations in dentin that induce dentinal defects or craze lines and microcracks.[2] Irrigants and medicaments used during chemico-mechanical preparation alter collagen structure, which contributes considerably to alteration of mechanical properties of dentin, thus precipitating fatigue crack propagation and hence susceptibility to vertical root fracture.[3]

Address for correspondence:
Dr. Parul Chauhan, House No. 668, Sector 9, Faridabad, Haryana, India.
E-mail: cparul39@gmail.com

Date of submission : 25.04.2019
Review completed : 02.05.2020
Date of acceptance : 04.07.2020
Published : 04.08.2020

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Chauhan P, Garg A, Mittal R, Kumar H. A comparative evaluation of fracture resistance of endodontically treated teeth using four different intraorifice barriers: An in vitro study. J Conserv Dent 2019;22:420-4.
As reasons for tooth weakening and susceptibility to fracture are multifactorial, the focus should be on the reinforcement of both remaining coronal tooth structure and on radicular tooth structure. Intracoronar strengthening of teeth is important to protect them against fracture, particularly in posterior teeth where stresses generated by occlusal forces can lead to fracture of unprotected cusps.

Bonding endodontic obturation material to radicular dentin may also increase the fracture resistance of root. It has been advocated that to reinforce roots, stress concentrations at dentin-material interface should preferably be minimized by using materials with a modulus of elasticity similar to dentin.

The concept of intraorifice barriers was first proposed by Roghanizad and Jones for preventing coronal microleakage and favorable results were reported. In a study by Nagas et al., placement of barrier material in the canal orifice has also been found to increase the fracture resistance of the teeth. As with increasing use of greater taper instrumentation, there is more widening at coronal third, so focus should be on reinforcing of this weakened portion. Using materials with a modulus of elasticity and compressive strength close to dentin and which can bond well to dentinal walls of root canal in the orifice, may not only provide good coronal seal but may also provide stiffness and resistance against forces that generate root fractures. Conventionally, few materials such as GIC, RMGIC, composites have been evaluated for their use as intraoffice barrier, but not many studies have reported the use of Biodentine as a barrier material. As it has a low modulus of elasticity and has been successfully evaluated for its reinforcing effect on immature teeth when used in apexification, so it might give favorable results as intraorifice barrier. Hence, the present study was designed to evaluate and compare fracture resistance of endodontically treated teeth using Biodentine, Conventional glass ionomer cement (GIC), resin-modified glass ionomer cement (RMGIC) and nanohybrid composite as intraorifice barriers.

**MATERIALS AND METHODS**

Fifty permanent single-rooted, mandibular premolars with a single canal and approximately the same dimension were selected. Radiographs were taken to confirm a single canal. Teeth with crack lines, internal or external resorption, curved roots, two or more canals were excluded.

Teeth were cleaned with 5.25% sodium hypochlorite and stored in distilled water with 0.02% thymol until use. The coronal portion of each tooth was resected at the level of cementoenamel junction using a bur in a high-speed handpiece and water coolant.

Working length was determined using a #10 K file, which was introduced into the root canal until it became visible at the apical foramen. Working length was established 1 mm short of this length. Root canals were instrumented with hand file up to #20 K followed by rotary Protaper universal system (Dentsply Maillefer, Ballaigues, Switzerland) in a sequential manner till F3 with endo motor (E-connect Pro, Orikam Healthcare India Pvt. Ltd., India) using crown down technique as per the manufacturer’s instructions. During instrumentation, canals were irrigated with 5 ml of 5.25% sodium hypochlorite after each change of file and final irrigation was performed using 5 ml of 17% ethylenediaminetetraacetic acid. Finally, canals were flushed with 10 ml of distilled water. The canals were dried, and obturation was done using corresponding sized F3 gutta-percha (Dentsply Maillefer, Ballaigues, Switzerland) and AH Plus sealer (De Trey-Dentsply, Konstanz, Germany). Excess gutta-percha was seared off with a hot instrument and burnished till the level of the orifice. Samples were then stored in an incubator (Alcor, India) at 37°C for 8 h to allow a complete set of the sealer.

Then, coronal 3 mm of root canal obturation was removed in all experimental groups with the help of a heated plugger. A cotton pellet soaked in 70% ethanol was used to remove any sealer or gutta-percha remnants from the prepared space. Specimens were divided into four experimental groups and one control group of 10 samples each according to intraorifice barrier material used over obturation as follows:

- **Group 1-Biodentine (Septodont, Saint Maur des Fossés, France) (n = 10):** Biodentine was mixed according to the manufacturer’s recommendation. It was placed using a plastic filling instrument and condensed using a plugger.
- **Group 2-Conventional GIC (GC Gold Label 2 Universal**
restorative GIC) \((n = 10)\): After surface treatment with polyacrylic acid, cement was mixed according to the manufacturer’s instructions, and was placed into the prepared space using a cement carrier followed by application of petroleum jelly after initial set

- Group 3-Resin Modified GIC (GC Gold Label 2 LC) \((n = 10)\): After conditioning the cavity with GC conditioner, cement was mixed according to the manufacturer’s instructions, was placed in the intraorifice space with cement carrier and was light-cured for 20 s
- Group 4-Nanohybrid Composite (Filtek Z350 XT, 3M ESPE) \((n = 10)\): Two coats of self-etch dental adhesive (single bond universal, 3M, ESPE) were applied to the cavity surface for 20 s and dried using air for 5 s. It was then light-cured for 10 s. The prepared intraorifice space was then restored with nanohybrid composite using 2 increments of 1.5 mm each and light-cured
- Group 5-Control group \((n = 10)\): Coronal 3 mm of gutta-percha was not removed, and no intraorifice barrier was placed.

After the placement of the intraorifice barrier materials, all the specimens were stored at 37°C and 100% humidity to allow the materials to set completely.

The apical root end of each tooth was aligned vertically along their long axis in self-curing acrylic blocks, leaving coronal 9 mm of each root exposed. Specimens were mounted on the universal testing machine (ZWICK, Spectrolab, Delhi, India) [Figures 1c, d and 2b]. A stainless steel loading fixture tip was centered over canal opening over intraorifice barrier material, and a compressive force was applied at a crosshead speed of 1 mm/min until fracture occurred. The force necessary to fracture each specimen was recorded in newton (N).

**RESULTS**

Results were statistically analyzed using SPSS version 21. Overall group comparison of fracture resistance was made using one-way analysis of variance test. Intergroup comparison was made using *post hoc* pairwise comparison using Tukey’s test. The level of statistical significance was set at 0.05. The mean and standard deviations of four experimental groups and the control group were calculated [Table 1]. The mean fracture resistance of all groups was found to be significantly different from each other. Group 1 showed the highest mean fracture resistance, followed by Group 2>Group 4>Group 3>Group 5. *Post hoc* Tukey’s test [Table 2] showed that mean fracture resistance of experimental group specimens were found to be significantly higher than that of control group specimens. Furthermore, the mean fracture resistance of Biodentine was found to be significantly higher than that of RMGIC specimens \((P = 0.04)\). No statistically significant difference could be found between Group 1, 2, and 4 specimens. Mean fracture resistance of RMGIC did not show any significant difference with Conventional GIC and Nanohybrid composite.

**DISCUSSION**

With the advent of the use of rotary instruments with tapers ranging from 0.04 to 0.12,[11] the resultant wider preparation may predispose root to vertical fracture due to excessive removal of root canal dentin, especially in the cervical region.[12] Adjunctive use of irrigating solutions and intracanal medicaments for disinfection may also significantly reduce microhardness of root canal dentin making them prone to fracture.[13] Hence, the focus should be on the reinforcement of not only coronal structure but radicular portion as well. In order to minimize the risk of

![Figure 2: (a) Armamentarium. (b) Universal testing machine](image)

**Table 1:** Mean values of fracture resistance and standard deviations of all groups

| Group       | Mean   | SD     | Minimum | Maximum |
|-------------|--------|--------|---------|---------|
| Group 1     | 458.50 | 130.08 | 295.40  | 695.90  |
| BIODENTINE  |        |        |         |         |
| Group 2     | 448.18 | 102.60 | 296.60  | 589.50  |
| Conventional GIC | |        |         |         |
| Group 3     | 337.83 | 28.01  | 307.60  | 404.67  |
| RMGIC       |        |        |         |         |
| Group 4     | 420.29 | 101.43 | 311.60  | 597.40  |
| Nanohybrid composite | |        |         |         |
| Group 5     | 203.09 | 62.12  | 121.80  | 298.90  |
| Control group | |        |         |         |

\(P\) Significance <0.0001

*One-way ANOVA. GIC: Conventional glass ionomer cement, RMGIC: Resin-modified glass ionomer cement, ANOVA: Analysis of variance, SD: Standard deviation

**Table 2:** *P* values of *post hoc* Tukey’s test for pairwise comparison

| Group 1 | Group 2 | Group 3 | Group 4 |
|---------|---------|---------|---------|
| Group 2 | 0.999, NS | -       | 0.073, NS | 0.885, NS |
| Group 3 | 0.04, S  | 0.073, NS | -       | 0.960, NS |
| Group 4 | 0.885, NS | 0.960, NS | 0.281, NS | -       |
| Group 5 | <0.001, S | <0.0001, S | 0.017, S | <0.0001, S |

S: Significant, NS: Not significant, HS: Highly significant
fracture in endodontically treated teeth, attempts should be made to reinforce these teeth using materials that can provide the required strength.

In our study, Biodentine was chosen as it is considered as a dentin replacement material and has shown to increase the fracture resistance of immature teeth when used as an apexification material in the past.\cite{10} It was compared with routinely used restorative materials when placed as intraorifice barrier.

After obturation, in all experimental groups, coronal 3 mm of gutta-percha was removed (in recommendation with Roghanizad and Jones), and space was filled with various materials to be used as intraorifice barriers.

Results showed that mean fracture resistance of all experimental specimens was significantly higher than that of control group specimens. Furthermore, the mean fracture resistance of Biodentine was found to be significantly higher than that of resin-modified GIC. The mean fracture resistance of RMGIC did not show any significant difference with conventional GIC and nanohybrid composite.

The results are in accordance with other few studies\cite{4,8} done, which showed that endodontically treated teeth with intraorifice barriers are more resistant to fracture compared to teeth in which no intraorifice barrier was used. In the control group, in which obturation was done using gutta-percha and AH Plus sealer without the placement of any intraorifice barrier, fracture resistance was the lowest. According to the results of the present study, the mean fracture resistance value of teeth with the Biodentine group showed the highest fracture resistance followed by conventional GIC, Nanohybrid composite, and RMGIC.

Biodentine is a calcium silicate-based material that can bond micromechanically to tooth surface without any surface preparation.\cite{8} This bonding could be explained on the fact that it releases large amounts of calcium and Silicon ions, which are taken up into root canal dentin. These ions get deposited on the surface and thereby improve interface bonding between biodentine and phosphate-rich tooth surface. Furthermore, its small and uniform particle size allows it to penetrate easily into dentinal tubules improving its bonding.\cite{10} Higher fracture resistance in the present study may be attributed to its good bonding with tooth and because mechanical properties of Biodentine are similar to that of dentin. Its elastic modulus is 22 GPa, which is close to that of dentin (18.5 GPa).\cite{11} Having elastic modulus similar to dentin helps in the flexion of restorative material at the cervical region and results in a lesser amount of tensile stresses forming at the tooth restoration interface. Furthermore, biodentine has a compressive strength of 300 MPa, which is near to dentin (297 MPa). This allows for even distribution of stresses along the tooth-restoration interface during occlusal loading.\cite{8}

Contrary to results of the present study, in a study by Yasa et al.,\cite{9} teeth with biodentine as intraorifice barrier showed lower fracture strength than teeth with composite resin although the difference in their mean strength was insignificant. Similarly, in a study by Mahalakshmi et al.\cite{8} teeth with biodentine demonstrated lower fracture resistance value compared to teeth with composite resin. However, the difference was again found to be insignificant. Statistically insignificant values could be attributed to the difference in sample size as large sample size was selected in the above-mentioned studies.

In the present study, conventional GIC showed the second-highest mean fracture strength following Biodentine with the difference between their mean fracture strength being nonsignificant. The reason for the good fracture strength of Conventional GIC may probably be due to its chemical adhesion to mineralized dental tissues, high tensile strength, and elastic modulus close to dentin. Even though GIC has a modulus of elasticity (15 MPa) close to dentin, it shows lower compressive strength.\cite{13} However, when used under direct occlusal loading areas, it may fracture, but when used as a base under restorations, it has been found to increase resistance to fracture of endodontically treated teeth. Thus, it could be used as an intraorifice barrier material in providing strength in the cervical portion of these teeth.\cite{16}

Composite resins used for posterior restorations show high compressive strength. They reinforce dental structure as adhesive composite binds to cusps and decreases their flexion, which is considered to be the main cause of fracture in nonbonded restorations. Due to their low elastic modulus, composite resins can transmit stresses produced by compressive forces to adjacent dental tissues, thus reinforcing weakened tooth structure.\cite{17} In the present study, Nanohybrid composite was used, which has high filler content, which improves its mechanical properties. Results are similar to the study by Aboobaker et al.\cite{9} who showed that composite resins were effective in increasing fracture resistance as intraorifice barrier compared to bonded amalgam and RMGIC.

RMGIC showed the lowest mean value of fracture strength among experimental groups in the present study, which was statistically significant to mean fracture resistance of biodentine. Although RMGIC has high flexural strength, good bonding, and modulus of elasticity close to dentin,\cite{18} their greater shrinkage upon polymerization and lower rigidity compared to composite resins are major drawbacks.\cite{18} Polymerization shrinkage results in gap formation due to debonding of restoration. Its significant difference from biodentine may be because Biodentine is a nonpolymer; hence, no shrinkage is exhibited by the material, and thus its adaptation and bonding to the tooth is not affected.
Lowest fracture strength was shown by the control group in which obturation was done, but no intraorifice barrier was used. This is in accordance with various studies\(^4,7\) who also found that fracture resistance of endodontically treated teeth decreases if intraorifice barrier is not placed.

**CONCLUSION**

Within limitations of this study, it can be inferred that the placement of an intraorifice barrier increases fracture resistance of endodontically treated teeth significantly. In the present study, Biodentine, conventional GIC, nanohybrid composite, and RMGIC all increased fracture resistance of teeth when used as intraorifice barriers and this increase in fracture resistance is material dependent. However, as not many studies have been done to assess the ability of intraorifice barriers in reinforcing endodontically treated teeth, more studies should be carried out using different restorative materials as intraorifice barriers.

**Financial support and sponsorship**
Nil.

**Conflicts of interest**
There are no conflicts of interest.

**REFERENCES**

1. Tang W, Wu Y, Smale R, J. Identifying and reducing risks for potential fractures in endodontically treated teeth. J Endod 2010;36:609-17.
2. Kim HC, Lee MJ, Yum J, Versluis A, Lee CJ, Kim BM. Potential relationship between design of nickel-titanium rotary instruments and vertical root fracture. J Endod 2010;36:1195-9.
3. Zapparoli D, Saquy PC, Cruz-Filho AM. Effect of sodium hypochlorite and EDTA irrigation, individually and in alternation, on dentin microhardness at the furcation area of mandibular molars. Braz Dent J 2012;23:654-8.
4. Nagas E, Uyanik O, Altundas E, Durmaz V, Cehreli ZC, Valitutti 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.
5. Roghanizad N, Jones JJ. Evaluation of coronal microleakage after endodontic treatment. J Endod 1996;22:471-3.
6. Abooobaker 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:ZC17-20.
7. 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.
8. Mahalakshmi V, Priyank H, Kumar C, Purbay S, Verma A. Evaluation of the effect of flowable composite, vitremer and bioceramic as intraorifice barriers on the fracture resistance and coronal microleakage of roots obturated with gutta percha – An in vitro study. Int J Contemp Med Res 2017;4:2004-10.
9. 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.
10. Bayram E, Bayram HM. Fracture resistance of immature teeth filled with mineral trioxide aggregate, bioaggregate, and bioceramic. Eur J Dent 2016;10:220-4.
11. Zandbiglari T, Davids H, Schäfer E. Influence of instrument taper on the resistance to fracture of endodontically treated roots. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;101:126-31.
12. Bier CA, Shemesh H, Tanomaru-Filho M, Wesselinik PR, Wu MK. The ability of different nickel-titanium rotary instruments to induce dentinal damage during canal preparation. J Endod 2009;35:236-8.
13. Saleh AA, Eltman WM. Effect of endodontic irrigation solutions on microhardness of root canal dentine. J Dent 1999;27:43-6.
14. Priyalakshmi S, Ranjan M. Review on Biodentine-A bioactive dentin substitute. J Dent Med Sci 2014;13:13-7.
15. Sakaguchi RL, Powers JM. Craig’s Restorative Dental Materials. 13th ed. Elsevier, United States; 2012. p. 327-47.
16. Trope M, Tronstad L. Resistance to fracture of endodontically treated premolars restored with glass ionomer cement or acid etch composite resin. J Endod 1991;17:257-9.
17. Monga P, Sharma V, Kumar S. Comparison of fracture resistance of endodontically treated teeth using different coronal restorative materials: An in vitro study. J Conserv Dent 2009;12:154-9.
18. Subash D, Shoba K, Amam S, Bharkadi SKI, Nimmi V, Abhilash R. Fracture resistance of endodontically treated teeth restored with biodentine, resin modified GIC and hybrid composite resin as a core material. J Clin Diagn Res 2017;11:ZC68-70.