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COMPARATIVE EVALUATION OF DIFFERENT INTRA-ORIFICE BARRIER ON FRACTURE RESISTANCE OF THE ENDODONTICALLY TREATED TEETH: AN IN-VITRO STUDY

Dental Science

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ABSTRACT

Aim: To evaluate the effect of different intra orifice barrier materials on fracture resistance of endodontically treated teeth and to determine which amongst them is best suitable.

Materials and Method: 45 mandibular premolars were decoronated to a standardized length, prepared and obturated with gutta-percha and AH Plus sealer. Except for control group, the coronal 3-mm gutta-percha was removed and filled with RMGIC and Biodentine. Fracture resistance of the specimens was tested.

Result: Fracture resistance of roots was affected significantly by the type of IOB used and the following pattern was observed: RMGIC > Biodentine > Control Group.

Conclusion: Presence of IOB increases the fracture resistance of endodontically treated teeth as compared to teeth without IOB. RMGIC showed the maximum reinforcement.

KEYWORDS

Endodontically treated teeth, reinforcement, RMGIC, Biodentine, Universal testing machine.

INTRODUCTION

Endodontically treated teeth are more susceptible to fracture than vital teeth, after the endodontic treatment, restoration and protection of the remaining teeth structure is mandatory, otherwise may lead to failure of root canal therapy [1,2,3].

Numerous previous clinical studies have reported that 11-13% of endodontically treated teeth are prone to vertical fractures [4,5]. **Bender and Freedland** stated the increased incidence of vertical fractures in teeth that have undergone endodontic treatment [6]. According to **Dietschi et al**., susceptibility of endodontically treated teeth to fracture is directly proportional to the coronal tissue lost as a result of carious lesion or restorative procedure [7]. The ability of tooth to resist occlusal forces depends on amount of remaining tooth structure.

Jhonson et al. stated that the major goal for endodontic therapy should be reinforcement of residual tooth structure. He also stated that the retention of an adhesive restoration is based on micro-mechanical retention, minimal invasive preparation with maximum conservation of dentinal tissue [8].

In order to reinforce the roots, stress concentration at dentin-material interface should be minimized by utilizing materials that have modulus of elasticity similar to dentine i.e. 14-16 GPa [9]. Root canal filling materials such as Resilon and gutta-percha have less modulus of elasticity compared to dentine and thus have little or no capacity for root reinforcement. Hence there is need for different materials and techniques to overcome the shortcomings of current endodontic filling materials to reinforce the roots [10].

Many studies have stated the use of intra coronal barriers in preventing coronal microleakage. Use of elastic materials with elastic moduli similar to the dentine seems logical to assume that intra orifice barriers can also provide stiffness against forces that generate root fractures, thus prevent vertical fracture to an extent [11].

Roghanizad and Jones advocated the placement of intra-orifice barrier (IOB) into root canals by replacing a part of coronal gutta-percha after obturation which can act as a second line of defence for the obturated teeth without permanent restoration [12].

Several materials have been used as an IOB such as cavit, resin based temporary restorative material, amalgam with varnish, MTA, glass ionomer cement and composite resins. Out of which most commonly used barrier are composites and glass ionomers [13].

RMGIC have high flexural strength and modulus of elasticity. Modulus of elasticity values are similar to dentin and withstand large amount of stresses, so proven to be the best material as IOB [10].

Biodentine is a newly introduced calcium silicate based material which micromechanically bonds to tooth surface. It has short setting time, high mechanical strength, good handling property and used as dentine replacement. It is used for perforation repair, retrograde surgical filling, external and internal resorption. But very few studies are there in terms of its role as an IOB [14].

Very few studies have assessed the reinforcement effects of IOB placed over root canal filling [1]. Hence, the objective of this study was to evaluate the newly introduced Biodentine with the best proven RMGIC on the fracture resistance of endodontically treated teeth.

METHODOLOGY

Sample preparation: Teeth were manually cleaned and decoronated using diamond disc at the level of 14mm from the apex for standardization. All the teeth were then examined under stereomicroscope at X10 magnification to ensure the absence of pre-existing fractures.

Root canal preparation: A number 10 k-type file was placed into the canal until visible at the apical foramen. The working length was determined visually and was kept 1mm short of the apex. Glide path was established by 2% k-files upto no.20 file. Biomechanical preparation was done using Universal Protaper rotary filing system upto F1 6% in conjunction with RC-help lubrication and 2ml of 5.25% sodium hypochlorite irrigation between each files. The root canals had a final irrigation of 5ml 17 % EDTA and 5ml 2.5% NaOCl. Canals were finally flushed with distilled water to avoid the prolonged effect of EDTA (RC-help) and NaOCl. The canals were dried with paper points. Obturaion was done by single cone technique using AH Plus sealer.

Group preparation and placement of the intra-orifice barrier: The prepared specimens were then randomly divided into 3 groups of 15 samples per group.

SR.NO.	GROUP	MATERIAL	NO. OF SPECIMEN
1	Group-1	Gutta-Percha	15
2	Group-2	RMGIC	15
3	Group-3	Biodentin	15

Group-1: Control group – The gutta percha was not removed and the teeth in this group did not receive any IOB material.

Group-2: RMGIC – The gutta-percha was removed upto 3mm depth by heated plugger and spoon excavator. The depth was measured using a graduated probe and the cavity was restored with RMGIC (GC Gold Label 2LC reinforced) in the ratio of 1:1. After placing the material into the cavities, mylar strips were held against the restored cavity to ensure smooth finish and then the specimens were light cured using LED curing light of 450 nm wavelength, for 20 seconds each.

Group-3: Biodentine – Similar procedure as of group-2 was used and the cavities were restored by Biodentine™ (Septodont). It was mixed as per manufacturer's instruction [29] in a device called Ultramat (SDI). The capsule was held in the capsule holder, it was carefully opened, ampule was broken and 5 drops of distilled water were introduced in the opened capsule. The capsule was then closed tightly and was placed in the Ultramat. The mixing was carried out at the speed of 4000-4200 rpm for 30secs. This lead to a homogenous mix of the Biodentine. The 15 IOB cavities of this group were restored with the obtained mix.

Mounting and testing of the samples: Teeth were marked at the 5mm level from the apex and were mounted in an acrylic block vertically upto the mark. The dimensions of the block were 20mm x 20mm x 20mm.

All the specimens were subjected to computerized software based universal testing machine (ACME, India. Model no. UNITEST-10) it has an accuracy of ±1%. The plunger arm of the machine was placed perpendicular to the barrier material placed within the sample. A vertical compressive force was applied at a crosshead speed of 1mm/min until the sample was fractured. This was determined visually as the sample exhibited vertical fracture line; also since the arrangement had a computerized demonstration of the force applied, the moment the sample was deformed the computer signalled the drop in the amount of force. The maximum fo

Analysis of data: Software statistical package for social sciences (SPSS) version 20.0 was used for statistical analysis. The force required to fracture the sample was recorded and subjected to statistical analysis using mean and standard deviation. Analysis of variance (ANOVA) and Tukey's test was applied to find the significant difference between the different groups.

RESULTS

Table No.1: Master chart showing the specimen wise readings of the force necessary to fracture specimen in different test and control groups.

Specimen No.	Control	RMGIC	Biodentine
1	243.20	399.55	567.75
2	184.25	464.80	335.45
3	227.35	708.50	605.55
4	189.40	571.50	498.90
5	221.70	595.00	438.40
6	185.60	983.85	770.65
7	220.50	278.40	668.65
8	235.45	975.60	744.10
9	195.20	514.60	442.30
10	185.20	547.10	557.35
11	215.35	584.30	492.00
12	200.65	698.60	519.30
13	190.45	754.50	457.25
14	215.85	845.45	428.15
15	247.95	924.85	545.30

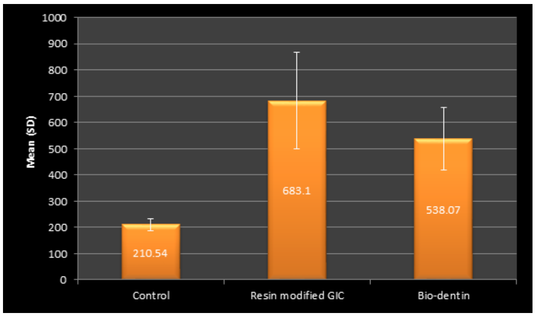
Table No.2: Comparison of the effect of different intra orifice barrier materials on fracture resistance in terms of {Mean (SD)} of endodontically treated teeth using ANOVA test

Groups	N	Mean	Std. Deviation	F value	P value
Control	15	210.54	22.011	54.236	<0.001**
Resin modified GIC	15	683.10	183.562		
Bio-dentin	15	538.07	120.189		
Total	45	477.24	235.435		

Table No.3: The inter-group comparison of the different groups using Tukey's post hoc analysis.

	Control	RMGIC	Biodentine
Control	-	<0.001**	<0.001**
RMGIC	<0.001**	-	0.009*
Biodentine	<0.001**	0.009*	-

Graph No.1: Bar graph depicting comparison of load bearing strength values amongst the groups.



DISCUSSION

Endodontic treatment needs enlargement of the coronal third of the root canal space. However, extensive use of rotary instruments during preparation of the root canal space by cutting the dentin to gain straight lines access weakens the root structure [15,16,17], causes desiccation and dehydration of the dentin [18,19]. This unavoidable loss of dentine weakens the root and creates increased susceptibility to fracture [20]. There is evidence that these teeth have reduced levels of proprioception which could have impaired normal protective reflexes which leads to fracture [21].

Rundquist et al. (2006) stated that with increasing taper, root stresses decreased during root filling but tended to increase for masticatory loading, resulting fracture originating in the cervical portion [22].

Zandbiglari et al. (2006) also observed that roots get significantly weakened with the use of greater taper instruments and obturation with AH Plus sealer was not able to increase the fracture resistance [23].

Obturation is one of the most important steps in endodontic treatment. Gutta-percha with root canal sealer is seen to be most commonly used root canal filling material. Many studies have shown that the root canal filling material i.e gutta-percha or resilon along with sealer have some limitations, low interfacial strength to radicular dentine which is not enough to reinforce the root structure so as to prevent vertical root fracture [24].

Nagas et al. has mentioned that the IOB with highest modulus of elasticity than these root canal filling materials can additionally reinforce the residual tooth structure; thereby preventing vertical root fracture to an extent. These materials can provide stiffness against the forces that generate root fracture [25].

The IOB concept was introduced by **Rohganizhad and Jhones** to prevent coronal microleakage. They advocated the placement of IOB into root canals by replacing a part of coronal gutta-percha after obturation. They suggested the 3mm thickness of material coronally is adequate to provide a good seal and also easy to remove should re-treatment be needed [12].

Nagas et al. showed that the IOB could also be used to provide resistance against forces that generate root fractures. He stated that the reinforcing effect was material dependent [25].

In-order to reinforce the roots, stress concentrations at dentin-material interface should be minimized by utilizing materials that have modulus of elasticity similar to dentine i.e. 14 - 16 GPa. Root canal filling materials such as Resilon and gutta-percha have low modulus of elasticity compared to dentine and thus have little or no capacity for root reinforcement [24].

One of the goals of root canal treatment is to reinforce endodontically treated root. Many studies when compared the root canal treated teeth with IOB and without IOB, stated that there is increase in fracture resistance in teeth with IOB [1,2,13,25,26,27,28,29].

Several materials have been used as IOB such as cavit, resin based temporary restorative material, bonded amalgam, GIC, composite resin, MTA. They are routinely used for restorative procedures due to good sealing ability, but they have poor physical properties [30,31,32]. In the present in-vitro study RMGIC and Biodentine were used as IOB materials. 45 mandibular premolars with single root and single canal were chosen. Endodontic preparation was done using Universal ProTaper 6% upto F1 file. Obturation was carried out by single cone technique using AH Plus a sealer. 3mm depth of gutta-percha was removed with heated plugger and the resultant cavity was restored with the respective IOB material except for the Control group.

The specimens were embedded in the self curing acrylic blocks. Linear compressive loading was applied at the crosshead speed of 1mm/min using universal testing machine. This is the most widely used technique for checking fracture resistance of endodontically treated teeth. Several studies have shown that applying force to the long axis of the tooth transmits the force uniformly [33,34,35]. The force necessary to fracture the specimen was recorded in newtons (N). The readings were subjected to statistical analysis.

Gutta-percha combined with AH Plus sealer is the most commonly used obturating material. In this study, AH Plus was used as a sealer with gutta-percha as AH Plus epoxy resin based sealer has the highest bond strength to dentine and to gutta-percha.

Nagas et al. has mentioned that the IOB materials with highest modulus of elasticity than these root canal filling materials can additionally reinforce the residual tooth structure; thereby preventing vertical root fracture to an extent. These materials can provide stiffness against the forces that generate root fracture [25].

Many studies stated that, the placement of IOB act as a second line of defence for the obturation of the teeth without permanent restoration. **Gupta et al**. stated that the presence of IOB strengthens the fracture resistance of endodontically treated teeth as compared to endodontically treated teeth without barriers [1]. So the present study evaluated the ability of IOB materials i.e RMGIC and Biodentine.

Resin modified glass ionomer cements are class of hybrid material created by modifying GIC with the addition of monomer component 2-HEMA (hydroxyl ethylene methyl acrylate) and associated initiator system. They are said to overcome the problems of low mechanical strength and low moisture sensitivity associated with GIC while retaining their advantages. In addition to ionic bonding RMGIC adhere to dentine by micro-mechanical retention [36]. Its modulus of elasticity is 10-14 GPa [37]; which is very similar to dentine and thus can withstands large amount of stresses. Therefore, due to its high flexural strength and modulus of elasticity this material is proven to be the best material as IOB [38,39,40,41].

Biodentine is a newly introduced calcium-silicate based material which micro-mechanically bonds to the tooth surface without surface preparation. It has improved physio-chemical properties when compared to other calcium-silicate based materials with advantages like short setting-time and high mechanical strength which makes it easier to handle and compatible for restoring clinical cases of dentine replacement. It is used for perforation repair, retrograde surgical filling, internal and external resorption [14,42]. But studies are scarce in terms of its role as an IOB.

As it is mentioned that the use of restorative material with high elastic modulus can provide stiffness against the forces that generate root fracture, present study tested the materials for the role in reinforcing the root structure. So this study was undertaken to compare Biodentine as an IOB with well proven RMGIC.

In the results of our study, the fracture strength values of the individual specimen were as given in the master chart **(Table No.01)**. The test groups revealed that fracture resistance of the roots was significantly affected by the type of IOB used. Both RMGIC and Biodentine significantly increased the fracture resistance of the root specimens.

Analysis of variance (ANOVA) was used to find the significance of study parameters between the groups i.e for inter group analysis. The mean values were calculated group wise **(Table No.02)**. RMGIC showed the highest fracture resistance (683.10 N) followed by Biodentine (538.07 N). Whereas, the Control group (210.54 N) showed the least strength to the endodontically treated specimen.

In the present study, in Group I (Control) where the core material was not able to increase the root fracture resistance where IOB was not used. Thus it was seen that, this combination alone was not able to increase the root fracture resistance in all the samples of the Control group. This confirms the findings of the previous studies done by **Ribeiro et al**. and **Gesi et al**. who reported that the gutta-percha combined with endodontic sealer were not able to increase the root fracture resistance [43,23,44].

Also, **Gesi et al**. stated that gutta-percha and sealers have low interfacial strength to radicular dentine which is not enough to reinforce the root structures so as to prevent vertical root fracture [24].

Zandbiglari et al. also proposed that the roots were weakened with the employment of greater taper instruments and obturation alone, with GP and AH Plus sealer did not enhance the fracture resistance [23].

The **Table No.02** shows the mean values of all the groups, Group I (Control) = 210.54 N, Group II (RMGIC) = 683.10 N and Group III (Biodentine) = 538.07 N. This shows that the maximum fracture resistance values are seen in group II i.e RMGIC and lowest values are seen in the Control group.

Further Tukey's post hoc analysis was carried out since the values of ANOVA test were significant. The obtained values of significance are as shown in the **Table No.03.** It indicated that both the IOB materials i.e RMGIC and Biodentine significantly increased the fracture resistance than teeth without the IOB.

In the present study, the fracture strength values of test groups revealed that the fracture resistance of the roots was significantly affected by the type of IOB used. Both the RMGIC and Biodentine significantly increased the fracture resistance of root specimen as compared to Control group. Maximum fracture resistance values were seen in Group II (RMGIC) followed by Group III (Biodentine). This is well depicted in the bar graph **(Graph No.01)**.

Our results are in conjunction with the previous studies conducted by **Nagas et al**. and **Aboobaker et al**., who have reported that RMGIC to be an effective IOB with significantly high resistance [25,2]. Also **Gupta et al**. in his study concluded the RMGIC as highest facture resistant material amongst their test groups [1].

RMGIC has high flexural strength and modulus of elasticity close to the dentine. Thus the material can withstand large amount of stress before transmitting to the root [41]. Moreover it chemically bonds with the dentinal surface rendering more strength at the dentine-cement interface [45]. All these properties might have resulted in RMGIC being the most fracture resistant material in the present study [10,37]. So it was confirmed in the present study that the use of restorative materials with high elastic moduli can provide stiffness against the forces that generate root fractures.

According to a study done by **Patrika Takaki et al**., the normal range of force applied by the human jaw while mastication is between 150 N to 350 N [46]. After comparing these values to the values obtained in the present study, it can be stated that endodontically treated teeth without intra-orifice barrier are more prone to fracture than the one with intra-orifice barrier; this is in conjunction with many of the previous studies. Moreover, it also suggests that both the test materials reinforced the endodontically treated samples adequately and that it is necessary to place an IOB after subjecting the tooth to the endodontic treatment.

Thus, we can say that, for a material to reinforce the tooth structure, elastic properties of a material should approximate those to the tooth structure so that lesser amount of tensile stresses will form at the tooth-restoration interface and marginal degradation which occurs due to mechanical change in the shape of the restoration will get minimized. The stresses created from occlusal loads will be distributed more evenly along the tooth-restoration interface and the whole tooth restoration system will act as a single unit (monoblock effect) which will improve fracture strength [13].

CONCLUSION

Within the limitations of this study, it might be concluded that presence of IOB increases the fracture resistance of endodontically treated teeth as compared to teeth without IOB. Present study indicated that both RMGIC and Biodentine have increased the fracture resistance in the teeth than teeth without IOB. Present study showed highest fracture resistance with RMGIC followed by Biodentine when compared to teeth without IOB. Hence it can be said that, fracture resistance of the root was significantly affected by type of IOB used.

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