

Evaluation Of Root Reinforcement Potential Of Different Intraorifice Barriers In Gutta Percha Obturated Root Canals - An In Vitro Study

Research Article

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Abstract

Introduction: The aim of the present study was to evaluate the efficiency of different intraorifice barriers in providing fracture resistance to endodontically treated roots.

Methods: Sixty extracted human mandibular teeth instrumented by crown down technique with Protaper rotary files and obturated Gutta-Percha and AH resin sealer. Coronal 3mm of gutta percha was removed with the aid of Peeso reamers. The specimens were sub grouped into 4 groups of 15 teeth in each group. Mineral Trioxide Aggregate, Resin Modified Glass Ionomer Cement, Composite were used to fill the space. The force necessary to fracture each root was recorded by using Universal Testing Machine. The results were analyzed by one way Analysis of Variance and pairwise by Student's t-test.

Results: Composite and Resin Modified Glass Ionomer Cement group showed higher fracture resistance, but the difference was not statistically significant. Mineral trioxide group showed an increase in fracture resistance of teeth but was statistically less significant when compared to Composite and Resin Modified Glass Ionomer groups.

Conclusion: Reinforcement of obturated roots with Composite, Resin Modified Glass Ionomer Cement and Mineral Trioxide Aggregate as intraorifice barriers is a viable choice to reduce the occurrence of post endodontic root fracture.

Keywords: Intra Orifice Barriers; Root Canal; Reinforcement.

Introduction

Prognosis in Endodontic is dependant on several factors. Complete removal of microorganism by efficient biomechanical preparation and creating three dimensional hermetic seal with an obturating material thereby preventing leakage of fluids from oral cavity to periapical tissues by restoring the tooth with a material which strengthens the remaining tooth structure to withstand masticatory forces [1-4].

Of the various techniques in biomechanical preparation crown-down technique using rotary instruments is commonly used. It reduces cervical interferences, thereby allowing easy and free movement of instruments. This allows lowering the torque on the canal walls and also preventing the building up stresses on the file in the apical region [5]. Furthermore cervical flaring facilitates

working length determination [6]. At the same time because of cervical flaring there is a notable reduction of the residual dentin thickness (RDT) thereby increasing the chance of vertical root fractures [7]. Hence RDT could be detrimental infracture resistance of tooth [8].

The modulus of elasticity of dentin is 14-16 giga pascals and to limit stress concentrations and to strengthen the roots a material of a similar value should be preferred at dentin material interface [9]. The most commonly materials like resilon despite having higher flexural modulus than Gutta-percha didn't reinforce roots [10].

Role of Coronal restoration is eminent in preventing the movement of microorganisms or toxins into the root canal filling or into the peri apical tissues [11]. No root canal sealer-cement or

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obturation technique completely prevents leakage through the canal, hence newer materials or techniques are being studied [12].

One approach to improving the coronal seal has been to place an additional layer of restorative material, or a double seal directly into the orifices of the root canals as an Intraorifice barrier [12]. Hence intraorifice barriers should not only prevent coronal microleakage but also reinforce the strength to resist root fracture [13].

Several materials have been used in an attempt to provide an intra-coronal seal to prevent microleakage, such as, amalgam, intermediate restorative material, Super-EBA, composite resin, glass-ionomer cement, and mineral trioxide aggregate [14-18].

Both Composites and resin modified glass ionomer cement are known to have high flexural strength and high modulus of elasticity. The elastic moduli values are similar to dentin and withstand stress [19-21].

MTA as an intracanal medicament was able to prevent microleakage. The setting reaction includes formation of apatite crystals within the collagen [22].

Hence these three materials were evaluated in this study. Various methods have been used such as Photoelastic studies, 3-dimensional finite element analysis, to test for the fracture resistance of teeth but the compressive load applied along the long axis of the tooth by the Universal Testing Machine used in this study transmits the forces uniformly [23, 24].

Therefore, the purpose of the present study is to evaluate the root reinforcement potential of the three different intraorifice barriers placed over gutta percha obturated root canals by using a Universal Testing Machine.

Methods

Sixty freshly extracted human mandibular premolars needed for this institutionally approved study and these were obtained from patients undergoing tooth extraction for orthodontic purposes. Informed consent was taken from all the patients before extraction. The specimens were selected based on their macroscopically similar size and straight roots. The mesio-distal and bucco-lingual diameters were standardized by using a digital caliper. The mean mesiodistal and buccolingual dimensions were obtained as 7.5 and 8.5 mm respectively. Roots presenting with less than $\pm 10\%$ difference from those values were used. They were cleaned and stored in 10% Formalin. Thereafter, all the specimens were examined under a surgical microscope to ensure absence of cracks.

Specimen Preparation

The crowns of all sixty mandibular premolar teeth were decoronated using a diamond disc mounted on a straight micro-motor hand piece. The root length was standardized to 14mm. Pulpal remnants were removed by barbed broaches. With a no.10 K-file patency of canal is checked by passing until it reaches apical foramen and it should be visible. Working length is kept 1mm short of apical foramen. The biomechanical preparation was done with Protaper Rotary files (Dentsply) in the following sequence of

Sx, S1, S2, F1, F2 and F3 according to the manufacturer's instructions in conjunction with 15% Ethylenediaminetetraacetic acid (RC Prep) lubrication and copious irrigation is done with 2 ml of 5.25% Sodium Hypochlorite irrigation in between. Finally 5ml of 5.25% Sodium Hypochlorite is used to flush the canals and dried with paper points.

The specimens were then obturated with gutta percha and resin sealer (AH Plus, Dentsply). The master cone was selected and introduced into the root canal to full working length and was checked for tugback. According to the manufacturer's recommendations AH Plus root canal sealer was mixed in equal volume units (1:1) of Paste A and Paste B on a mixing pad using a metal spatula to a homogeneous consistency. With a K-file in a counter clockwise direction AH sealer is applied on to the walls of root canal. The master cone was coated with AH-Plus sealer placed into the root canal until the working length was reached. The lateral compaction was done using standardized finger spreaders and accessory GP cones coated with AH-Plus sealer was used.

Except for the control specimens, coronal 3mm of root fillings was removed with the aid of Peeso reamers (Easy Post, Dentsply). Microbrushes moistened with alcohol (70%) is used to remove remnants of gutta-percha and sealer.

Test groups

The specimens were randomly subgrouped with respect to the intraorifice barriers material placed over root fillings (n = 15/group):

1. Group A: Mineral Trioxide Aggregate (ProRoot MTA, Dentsply)
2. Group B: Resin Modified Glass Ionomer Cement (Vitremer, 3M ESPE)
3. Group C: Composite (Filtek 250, 3M ESPE)
4. Group D: No Barrier (Control)

Group A: Mineral Trioxide Aggregate (ProRoot MTA, Dentsply)

White Mineral Trioxide powder was incorporated into the liquid using a stiff metal spatula on a glass slab for about one minute to ensure all the powder particles were hydrated and mixed into a thick, creamy consistency. It was then placed in the canal using a plastic filling instrument till the material was flush with the sectioned root surface.

Group B: Resin Modified Glass Ionomer Cement (Vitremer, 3M ESPE) Mixed according to recommended proportion of one scoop powder and one drop of liquid with a cement spatula for 10-15 seconds till all the powder was incorporated into the liquid. The mixed cement had a smooth consistency and glossy appearance. It was then placed in the prepared specimen using a plastic filling instrument and light cured for 30 seconds.

Group C: Composite (Filtek 250, 3M ESPE)

Dentin were conditioned with 36% phosphoric acid for 15 secs. It was then rinsed for 10secs and excess moisture was blot dried with cotton pellets. Bonding agent was applied using micro brushes and left undisturbed for 20 seconds and gently air dried to

remove excess solvent for 5 seconds. Light cured for 10 seconds. Increments of Z- 250(3M ESPE) were placed. Each increment (1.5mm) was light-cured for 40 seconds.

After placement of the intraorifice barrier materials, specimens were stored at 37°C and 100% humidity in distilled water for one week to allow the materials to set completely.

Fracture test:

With about 9mm of each root exposed apical root ends were embedded in self-cure acrylic blocks. Thereafter, the specimens were mounted in a Universal Testing Machine. A steel spherical tip of 2 mm diameter fixed to the upper arm of the universal testing machine was centered over the canal opening which was set to deliver an increasing load until fracture occurred. Speed of cross head is set to 1mm/min and along axis of the tooth load is applied. Unit of force needed for fracture was recorded in Newtons. One-Way ANOVA and Student's t-test were used to determine level of significance between different groups.

Results

Table 1 shows fracture resistance values of test specimens presented as Mean and Standard deviation.

- In the Control group the values ranged from 342.1 N to 1568.5 N with a mean of 891.7. This group demonstrated the least amount of fracture resistance.
- In the MTA group the values ranged from 997.9 N to 1996.2 N with a mean of 1,349.20
- In the RMGIC group the values ranged from 1169.4 N to 3879.6 N with a mean of 2,498.19
- In the Composite group the values ranged from 1432.1 N to 3268.4 N with a mean of 2,498.19.

Table 2 shows the parameter was analyzed by One way Analysis of Variance. Due to significance in ANOVA this parameter was

further analyzed pairwise by Student's t-test and the p value-0.05 was obtained.

- All three groups; MTA, RMGIC and Composite show significantly higher fracture resistance when compared to the Control group.
- Mean difference between MTA and Control: -508.14 with p value- 0.034
- Mean difference between RMGIC and Control- 1358.5667 with p value <0.001
- Mean difference between Composite and Control- 1606.4933 with p value <0.001
- Composite and RMGIC group show significantly higher fracture resistance than MTA group. Mean difference between RMGIC and MTA- 850.4267 with p value <0.001 and mean difference between Composite and MTA being 1098.3533 with p value <0.001.
- Composite and RMGIC groups showed comparable fracture resistance as the difference between their values was statistically insignificant. Mean difference between Composite and RMGIC-247.9267 with p value-0.523.

Discussion

The fracture resistance of endodontically treated depends on the remaining dentin thickness or tooth structure [25]. The use of irrigating solutions has shown to significantly reduce the micro-hardness of the dentin can be induced by the use of irrigating solutions during endodontic treatment. The loss of water and gutta-percha condensation procedures may also contribute to the weakness of these teeth [26, 27].

Four millimeters above and also apical to the crestal bone is considered to be critical for the tooth to resist fracture. Currently rotary instruments such as Gates Glidden burs, orifice shapers, and profile orificeshaper are commonly used [28]. Isom et al. found that significant amount of dentin is removed at the furcation area while using Gates Glidden burs of no.#2 and #3 [29].

Table 1. Fracture Resistance Values (N) of Test Specimens Presented as Mean and Standard Deviation.

Group	n	Mean	SD	Median	Min.	Max.	'p' value
Control	15	891.7	339.494	834.2	342.1	1568.5	<0.001
MTA	15	1,399.84	236.317	1,349.20	997.9	1996.2	
RMGIC	15	2,250.27	739.038	2,438.20	1169.4	3879.6	
Composite	15	2,498.19	514.492	2,523.40	1432.1	3268.4	

Table 2. Fracture Resistance Values Analysis Using One way Analysis of Variance.

(I) Group	(J) Group	Mean Difference (I-J)	'p' value	95% Confidence Interval	
				Lower Bound	Upper Bound
Control	MTA	-508.14	0.034	-987.201	-29.079
	RMGIC	-1358.567	<0.001	-1837.627	-879.506
	Composite	-1606.493	<0.001	-2085.554	-1127.433
MTA	RMGIC	-850.427	<0.001	-1329.487	-371.366
	Composite	-1098.353	<0.001	-1577.414	-619.293
RMGIC	Composite	-247.927	0.523	-726.987	-231.134

Clinicians have long sought to reinforce the remaining tooth structure in order to overcome the reduced fracture resistance of endodontically treated teeth. Gutta percha along with an insoluble sealer is an ideal choice for root obturation [30]. Nevertheless, it has failed to reinforce endodontically treated roots due to its inability to bond to the tooth structure [31]. Apart from gutta percha the other most commonly used obturating material is Resilon. Resilon is composed of a thermoplastic synthetic core containing bioactive glass, bismuth oxychloride, and barium sulfate. It has a dual-curing resin-based sealer [30]. It forms a bond between dentin, sealer and resilon, resulting in a “monoblock” effect between the intraradicular dentin and the root canal filling material [31].

Studies have shown that due to the presence of the monoblock effect the teeth are resistant to both bacterial leakage and root fracture compared with similar roots that are filled with conventional filling materials [32, 33]. On the contrary Stuart et al reported no significant differences in reinforcement of endodontically treated roots of immature teeth between Resilon and Gutta-percha when compared with unfilled controls [34]. Added to this Williams et al. reported that the stiffness of Resilon and Gutta-percha is not sufficient to strengthen roots after root canal therapy [10].

Another parameter which is important for the restorative success is the coronal seal. No matter what the obturation material used the importance of coronal seal has been increasingly recognized in the dental literature. If new microorganisms are allowed to reenter the cleaned and sealed canal space, post-treatment failure can occur.

Prevention of Coronal microleakage is an important factor associated with post endodontic restorations because endodontically treated teeth tend to be more porous thereby creating a path for entry and exit for bacteria and bacterial by-products [35]. Hence post endodontic failure could be because of delay in placing permanent restorative material, fractured coronal restoration, temporary restorative material lacking strength and improper margins for restoration [36].

Permanent restoration is done immediately to prevent coronal microleakage in these teeth. Although a higher success rate has been found in teeth with permanent restorations than in teeth with provisional restorations with regards to coronal microleakage they still showed microleakage when evaluated [37]. Amalgam when used for access restoration showed more coronal leakage than bonded amalgam [38]. Fabricating core build-ups with glass ionomer cements have shown microleakage from dissolution by saliva overtime and composites resins show polymerization shrinkage which is responsible for microleakage [39, 40]. Since the presently available methods have been found to be inadequate in preventing coronal microleakage, the intraorifice barriers were introduced as an additional method to circumvent this problem. An intra-orifice barrier not only can efficiently decrease coronal leakage in endodontically treated teeth by creating a double seal but also proven to reinforce endodontically treated roots preventing fractures [12, 13]. Hence for an ideal intraorifice barrier it should have workable properties, bond to tooth structure, prevent microleakage, reinforce root, should be able to differentiate from natural tooth structure and doesn't interfere with permanent restoration [41].

Hence the aim of this present study is to evaluate the efficiency

of the Intraorifice barriers in preventing coronal microleakage and ability of these to provide stiffness against forces that generate root fractures in endodontically treated teeth.

In this study for studying intraorifice barrier 3mm of Gutta percha is replaced by a restorative material at the orifice of the root canal. It has several advantages compared to other depths like easy to seal, accommodating bulk of material for retention and can be easily removed for retreatment [42-44].

Various materials have been used as an intraorifice barrier to provide coronal seal [14-18]. The materials evaluated in the study were Composite, Resin Modified Glass ionomer Cement and Mineral trioxide Aggregate.

Various methods have been used to evaluate fracture resistance of teeth under compressive load such as Photoelastic studies, 3-dimensional finite element analysis, but the compressive load applied along the long axis of the tooth by the Instron machine used in this study transmits the forces uniformly [19].

The results of the present study showed that composites and RMGIC significantly increased the fracture resistance of root canal treated teeth as compared to the control and MTA group. The difference between RMGIC and Composite was not statistically significant. This can be attributed to the ability of the restorative materials to bond to the tooth structure bringing about a Monoblock effect meaning ‘single unit’. They are classified as primary, secondary, or tertiary monoblock based on bonding wall and core material [45].

Composite restoration and RMGIC can be categorized under primary monoblock type and was found to be effective. There are conflicting results questioning the ability of bondable materials to form monoblock unit, but the present study is in acceptance with Wilkinson study suggesting the ability of composites to strengthen the roots presenting monoblock effect [45, 47, 48]. There was no significant statistical difference in fracture resistance between RMGIC and composite group. This can be attributed to the fact that apart from both being bonded restorations they also have been shown to have high flexural strength and high modulus of elasticity [19, 20]. Both materials are expected to withstand stress and prevent it transmitted to root since elastic modulus are similar to dentin [10]. Observations of this research are similar to the study done to evaluate the reinforcing effect of resin glass ionomer cement in the restoration of immature roots [46].

In addition, RMGIC has shown significant increase in fracture resistance in comparison to MTA and control group. This could be because of chemical bonding to dentin resulting in high adhesive strength [49]. The high adhesive strength could be attributed to slow rate acid base reaction resulting in availability of polyacid for longer duration [50].

The study also concluded that MTA significantly strengthened the root filled teeth when compared with the control group. This may be due to its elastic modulus 14,000–18,600 MPa, which is similar to that of dentin [45]. It could be because of formation of apatite-like interfacial deposits resulting from reaction of calcium and hydroxyl ions released with phosphate ions in dentinal fluid [50]. The results of this study are similar to the previous study showing significantly higher resistance to fracture compared with

those filled with calcium hydroxide or the controls [51]. Its ability could be because of high stiffness in compression [45].

Results of this study showed that the Mineral trioxide group showed higher fracture resistance when compared to the control but the values were significantly lesser than that of the composite and the resin modified glass ionomer group which could be explained based on the inability of this material to bond to the tooth structure [45] These findings were corroborated by Schmoldt et al who stated that MTA does not reinforce the root when compared with composite resin and fiber post [47].

Conclusion

The present study concluded that the intraorifice barriers were found to be advantageous in terms of increasing the fracture resistance of endodontically treated teeth. Furthermore, bonded restorations such as Composite and Resin Modified Glass Ionomer Cement have resulted in a higher fracture resistance than non-bonded restorations such as Mineral Trioxide Aggregate. The Instron machine used in the study to fracture the teeth applied non physiological forces to fracture the teeth which warrant the need for better techniques to simulate the forces encountered in the oral environment. Further laboratory research is needed with different materials and better techniques coupled with clinical trials to confirm these results and evaluate their relevance in treatment outcome. Under the conditions of the present ex-vivo evaluation, the following conclusions are drawn:

1. Composite, Resin Modified Glass Ionomer Cement and Mineral Trioxide Aggregate intraorifice barriers Placed over gutta percha obturated root canals had higher fracture resistance compared to that of without intraorifice barriers.
2. Fracture resistance of roots was significantly affected by the type of intraorifice barrier placed. Composite and RMGIC groups showed comparable fracture resistance as the difference between their values was statistically insignificant.
3. Mineral trioxide group also showed an increase in fracture resistance of teeth as compared to the control but the fracture resistance was significantly less than that of Composite and Resin Modified Glass Ionomer groups.
4. Bonded restorations such as Composite and Resin Modified Glass Ionomer cement demonstrated a higher fracture resistance in comparison with Non-bonded restorations like Mineral Trioxide aggregate.

Further laboratory research with different materials and techniques coupled with clinical trials is necessary to validate the results of this in vitro study.

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