

Reinforcement of Endodontically Treated Teeth by Different Intraorifice Barrier Materials

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Abstract

Background: Fracture incidences are more common in teeth with endodontic therapy and hence endodontic therapy should aim toward the reinforcement of such teeth by placing various restorative materials. **Aims:** Comparative evaluation of different intraorifice barrier material on strengthening the fracture resistance of teeth requiring endodontic therapy. **Methods:** Sixty extracted human mandibular premolars with one root were divided into four groups ($n = 15$); Group 1 - Light cured Glass ionomer cement, Group 2 - Nanohybrid composite (NHC), Group 3 - High copper amalgam, Group 4-Control. Decoronation of specimens was done to a standardized length of 14 mm and was instrumented up to International Organization for Standardization (ISO) #30 size master apical file. Gutta percha was used to carry out the obturation by the cold lateral compaction technique. With the exception of the control group, elimination of 3 mm obturation from the coronal portion was done and intraorifice barrier materials were placed. Universal Testing Machine was used for testing fracture resistance. **Statistical Analysis:** Analysis of variance was applied to analyze the data obtained and pairwise comparison was done by *post hoc* tukey's test ($P < 0.05$). **Results:** Better resistance to fracture incidence was seen with NHCs. Control group presented the least values. **Conclusion:** On placement of intraorifice barrier materials in teeth with endodontic therapy, there was a reduction in fracture incidence.

Keywords: Endodontically treated teeth, fracture resistance, intraorifice barrier

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INTRODUCTION

As compared to vital teeth, the substantial amount of diminution of dental tissues, dentinal desiccation, and obturation pressure increases the vulnerability of an endodontically treated teeth.^[1] Transient contacts between instruments and radicular dentin are created from the instrumentation of the root canals during cleaning and shaping that produces dentinal stresses like craze lines and microcracks.^[2] The usage of various kinds of intracanal irrigants and medicaments as an adjunct to chemo-mechanical preparation remodels the structure of dentinal collagen which in turn precipitates fatigue crack propagation thereby increasing the susceptibility to vertical root fracture.^[3] Fortifying the remaining tooth structure should be the primary intention of endodontic therapy.^[4] Gutta-percha owing to its low value of modulus of elasticity does not reinforce the root posttreatment.^[4] This necessitates the usage of different materials or techniques capable of combating the drawbacks of currently used endodontic obturating materials

and reinforcing the endodontically treated teeth, known as Intraorifice Barriers.^[5] Roghanizad and Jones are the pioneers to introduce the concept of intraorifice barriers for preventing coronal microleakage.^[6] The effect of forces generating root fractures gets nullified from the stiffness of restorative materials with high value of modulus of elasticity.^[7] Recently used greater taper instruments widens the coronal third of the root canal which necessitates the reinforcement of this weakened portion of the teeth. Improvement in coronal seal is seen with dental materials having bonding ability to dentin which further enhances the fracture resistance and decreases the fracture incidence.^[8]

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METHODS

Selection of specimens

Sixty extracted human mandibular single-rooted single canaled premolars with root curvature $<10^\circ$ were selected for the study. To establish a uniform root length of 14 mm for all the teeth, coronal reduction of samples were done. A digital caliper was used to measure the mesiodistal and buccolingual diameters of coronal aspect. Values of the mesiodistal and buccolingual dimensions on an average were obtained as 4.94 mm and 6.48 mm, respectively. A deviation of $\pm 10\%$ from these mean values obtained was considered as the exclusion criteria. To confirm the absence of preexisting fracture and craze lines, the assessment of all the samples was carried out with the help of magnification (10X) of a stereomicroscope.

Specimen preparation

The root surface was debrided of calculus and soft tissue deposits by scaling procedure. To achieve a uniform length of 14 mm, decoronation of specimens with a diamond disc was done. To evaluate the canal length, no. 10 K-file (Mani, Inc., Japan) was used. From the established canal length, 1 mm deduction was done to determine the working length. Root canal instrumentation was done with hand K-files (Mani, Inc., Japan) using step-back technique in conjunction with the use of RC-Prep. The apical preparation was done till #30 K-file and by employing the step-back technique the biomechanical preparation was finished off till #45 K-file. The irrigation protocol followed was 2 ml of 5.25% sodium hypochlorite for every change in instrument, followed by 5 ml 17% Ethylenediaminetetraacetic acid and a final flush of 10 ml of normal saline. To obturate the canal cold lateral compaction technique was employed using the gutta-percha (Dentsply Maillefer, Switzerland) and AH Plus sealer (Dentsply Maillefer, Switzerland), after drying the canals with absorbent paper points. To ensure proper and complete setting of the sealer, the specimen was stored in an incubator for 8 h.

Placement of intraorifice barrier materials

Excluding the specimens that served as control, 3 mm of obturation from coronal one-third of the root canal of all the other groups were removed with a red hot spoon excavator. Thereafter, to remove residual sealer microbrushes soaked in 70% alcohol were used. This was verified with a William's periodontal probe. Random allocation of the prepared specimens was done into four test groups, each group consisting of 15 specimens.

Group 1: Light cured Glass ionomer cement (LC GIC) (GC LC2, GC Corporation, Tokyo, Japan).

Powder and liquid ratio was kept at 2:1. Manipulation and placement into the canal orifices were done with a cement carrier instrument. 30 s of light-curing was done.

Group 2: Nanohybrid composite (NHC) (Filtek Z350 XT, 3M ESPE, USA).

Thirty-seven percent phosphoric acid gel was used as an etchant for 15 s. Distilled water was used for rinsing the

prepared intraorifice surface for 10 s. Cotton pellet was used for absorbing the excess moisture. Bonding agent was applied in a thin layer followed by curing for 30 s duration. NHC resin was placed in increments followed by 30 s of curing.

Group 3: High copper amalgam (serial digital interface gs80, Dental Avenue Pvt. Ltd., Mumbai, India).

Trituration of amalgam was carried out in an amalgamator and condensed into the intraorifice space.

Group 4: Control.

In this group, coronal 3 mm gutta-percha was left intact in place and intraorifice barrier material was not placed.

To ensure complete setting of all the materials, their storage was done in an incubator having 37°C temperature and 100% relative humidity for 7 days.

Mounting and testing of specimens

During their insertion in self-curing acrylic resin, it was ensured that the apical root tip was along their long axis. 3 mm of each root was left exposed above the acrylic resin. Universal Testing Machine (ACME India, Model: UNITEST) was used for mounting the specimens. Over the canal orifice, a custom stainless steel loading fixture with a spherical tip design measuring 2 mm in diameter was centrally positioned [Figure 1]. Maintaining a cross head speed of 1 mm/min, a compressive force was applied up to the point where the specimen fractured [Figure 2]. Newtons (N) values were used to measure the magnitude of forces which led to the fracture of each root specimen [Table 1].

The data were analyzed statistically using one-way analysis of variance (ANOVA) and *post hoc* Tukey's *t*-test.

RESULTS

The mean value of fracture resistance was 476.07 N for Group 1 (LC GIC), 514.60 N for Group 2 (NHC), 306.07 N for Group 3 (High copper amalgam), 221.93 N for



Figure 1: Mounted specimen on universal testing machine for assessing fracture resistance



Figure 2: Specimens that were fractured

Group 4 (Control) [Table 2]. The difference between LC GIC and NHC was not statistically significant ($P > 0.05$). Individually, LC GIC and NHC showed statistically significant differences when compared to high copper amalgam and control group in which the intraorifice barrier was not placed ($P < 0.05$).

DISCUSSION

Enormous eradication of radicular dentin, especially in the cervical region occurs from the greater taper of currently used rotary instruments ranging from 0.04 to 0.12, thereby leading to wider preparation predisposing to vertical root fracture.^[9,10] Remaining dentin thickness plays a pivotal role in strengthening the roots against masticatory forces and decreasing their fracture susceptibility. However, widening the coronal third of root canal to establish straight-line access, effective irrigation and adequate obturation, causes a substantial reduction in the remaining dentin thickness.^[11]

In transferring stresses from coronal to apical portion of the tooth, cemento-enamel junction has proven to be the most impeccable anatomical landmark. (Peri Cervical Dentin [PCD]); dentin near the alveolar crest, extending approximately 4 mm coronal and 4 mm apical to the crestal bone is a critical zone to transfer stresses and provide resistance to fracturing.^[12]

Hence, the placement of intraorifice barrier at cervical portion of the tooth compensates for loss of dentin (PCD) owing to the coronal flaring and leads to root strengthening. Thus, in the present study, the various intraorifice barrier materials have been placed in a thickness of 3 mm to compensate for the loss of PCD.

Growing attention is being given to postendodontic treatment procedures along with their impact on the prognosis of nonvital teeth.^[5] Teeth are reinforced against fracture after providing a restoration postendodontic treatment.^[5] The stress concentration at the dentin-material interface is reduced with the materials with a modulus of elasticity bearing similarity

Table 1: Fracture resistance values in newtons

	Group 1: LC GIC	Group 2: NHC	Group 3: Amalgam	Group 4: Control
1	486	518	512	250
2	548	522	271	260
3	416	453	304	245
4	495	539	350	234
5	500	545	325	228
6	490	540	250	190
7	530	482	300	200
8	420	512	220	215
9	456	550	263	230
10	476	530	360	225
11	426	564	267	112
12	400	486	245	208
13	488	525	332	250
14	440	490	257	234
15	570	463	335	248

LC GIC: Light cured glass ionomer cement, NHC: Nanohybrid composite

to that of dentin (14–16 GPa), at the cervical region the restorative material is flexed thereby generating lesser tension at the tooth-restoration interface. Therefore, when the tooth goes under occlusal loading stresses get uniformly distributed along the tooth-restoration interface.^[4,13] The present study evaluated the reinforcing ability of LC GIC, NHC, and High Copper Amalgam.

The inter-group comparison among the mean scores of the fracture resistance values by one way ANOVA test showed statistically significant difference among the four groups.

Table 3 shows the comparison of mean values between the four tested groups.

The findings of the present study were in congruity with the study conducted by Aboobaker *et al.*^[5]

The significant impact of the use of resin-based sealers and cold lateral compaction technique of obturation on strengthening the roots and that single cone obturation technique is subordinate to cold lateral compaction in terms of impact on strength is already been proven by few studies.^[14,15] Also cold lateral condensation and use of a resin-based sealer still remain one of the more widely preferred techniques by the general dental practitioners^[16] and the specialist practitioners as well. The usage of AH Plus sealer and cold lateral compaction technique of obturation has been demonstrated and explained in the present study. Biomechanical preparation was done by step back technique to provide a greater flare and thus facilitate packing of additional gutta-percha during the cold lateral compaction technique. However, in the present study, we noted that there was no significant increase in the fracture resistance of the roots even with the usage of core gutta-percha combined with the proven endodontic sealer (AH Plus). The importance of placing intraorifice barriers to substantiate the resistance of teeth that underwent endodontic therapy against getting fractured is validated and highlighted in the present study.

Table 2: Mean and standard deviation of the groups

	<i>n</i>	Mean±SD	95% CI for mean		<i>F</i>	<i>P</i>
			Lower bound	Upper bound		
LC GIC	15	476.07±50.015	448.37	503.76	116.289	0.001*
NHC	15	514.60±32.971	496.34	532.86		
Amalgam	15	306.07±70.940	266.78	345.35		
Control	15	221.93±36.319	201.82	242.05		

*Indicates significant at $P \leq 0.05$, One way ANOVA. ANOVA: Analysis of variance, LC GIC: Light cured glass ionomer cement, NHC: Nanohybrid composite, CI: Confidence interval, SD: Standard deviation

Table 3: Intergroup comparison by *post hoc* Tukey's test

(I) Groups	(J) Groups	Mean difference (I-J)	Significant	95% CI	
				Lower bound	Upper bound
LC GIC	NHC	-38.533	0.160	-86.73	9.67
	Amalgam	170.000*	0.000	121.80	218.20
	Control	254.133*	0.000	205.93	302.33
NHC	LC GIC	38.533	0.160	-9.67	86.73
	Amalgam	208.533*	0.000	160.33	256.73
	Control	292.667*	0.000	244.47	340.87
Amalgam	LC GIC	-170.000*	0.000	-218.20	-121.80
	NHC	-208.533*	0.000	-256.73	-160.33
	Control	84.133*	0.000	35.93	132.33
Control	LC GIC	-254.133*	0.000	-302.33	-205.93
	NHC	-292.667*	0.000	-340.87	-244.47
	Amalgam	-84.133*	0.000	-132.33	-35.93

*The mean difference is significant at the 0.05 level. LC GIC: Light cured glass ionomer cement, NHC: Nanohybrid composite, CI: Confidence interval

In the present study reinforcing ability of composites, GIC and amalgam have been evaluated which are feasible, easily available, cost-effective, and are the most commonly used postendodontic materials by the dentists in routine clinical practice.

Composite resins which are used as posterior restorative materials show high compressive strength. The adhesive properties of composite enable it to binds to the cusps. Due to bonding, their flexion decreases thereby leading to reinforcement of the tooth. Composite because of their low elastic modulus, transfer the stress of compression onto adjoining tooth structure, thereby buttressing weakened tooth structure.^[17] NHC has higher filler content; thereby improving and strengthening elastic modulus, micromechanical bonding, less shrinkage, good marginal seal reinforces and conserves the remaining tooth structure.^[1]

LC GIC shows strong chemical adhesion to tooth structure, high flexural and compressive strength and elastic modulus comparable to dentin. Its fracture resistance capacity was not significantly different from composite.^[5]

Amalgam is the most commonly used material over centuries exhibiting high compressive strength. However, being nonadherent to the tooth structure is its major limitation.^[17]

The control group exhibited the least fracture resistance in which intraorifice barrier was not placed after obturation.

This is in accordance with various studies^[1,4] wherein it was concluded that the fracture vulnerability of endodontically treated teeth is increased in the absence of an intraorifice barrier material.

Forces are transmitted uniformly when the forces are applied parallel to the long axis of the tooth. Hence, in the present study, the force application was done in a vertical orientation at a constant speed on the Universal Testing Machine.^[5] In our study, the angulation of force application was kept at 0° with 3 mm of root dentin uncovered by acrylic resin. This resulted in decreased incidence of bending moments and substantial generation of stress at the cervical region which made the experimental model used in the study more clinically relevant and resulted in lesser stress generation by the unrealistic bending moments.^[18] Compressive force was applied through the Universal Testing Machine as it is comparable to the masticatory forces which are also compressive in nature. However, nonphysiological nature of the force used and the application of compressive load at 0° instead of cyclic load testing at clinically meaningful load values constitute major limitations of the study.^[7] In the respective groups of both composite and GIC, high numerical values of fracture resistance was observed which is attributed to their superior adhesion to dentinal tissue.^[1]

The placement of intraorifice barrier enhances the fracture resistance of endodontically treated teeth as compared to

those endodontically treated teeth in which no intraorifice barrier is placed.

CONCLUSION

The highest fracture resistance was provided by NHC, followed by LC GIC and high copper amalgam. Keeping in mind the limitations of the study, it might be concluded that intraorifice barriers can be considered as feasible and practicable modality to reinforce the endodontically treated teeth and reduce the incidence of postendodontic root fractures. Due to their reasonably superior fracture resistance property in obturated teeth, NHC and LC GIC can be utilized as intraorifice barriers. Further research employing varied and newer types of dental materials and other parameters, in conjugation with clinical testings are required to validate the results of this *in vitro* study.

Ethical clearance

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Conflicts of interest

There are no conflicts of interest.

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