ISSN: 2582-9904

ORIGINAL RESEARCH

Fracture resistance of Endodontically treated teeth restored with Metal and Composite Endocrowns luted with two different luting agents : An in vitro study

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ABSTRACT

Background: Endodontically treated teeth should be properly restored to ensure longevity of the teeth. Many methods to restore ETT are reported in the literature. Endo crowns are a viable method of restoring ETT. There are no reports in the literature related to endo crowns fabricated with metal alloys and lab processed composite resins

Aim: The aim of the study is to evaluate in vitro, the fracture resistance of the endodontically treated teeth restored with Endo crowns fabricated using two different materials and luted with two different cements.

Material and method: Forty freshly extracted maxillary premolars were used as specimens for this in-vitro study. The specimens were endodontically treated with access opening in a class-I configuration. These specimens were randomly divided into four groups: MG, MR, CG and CR. The specimens were mounted in self-cure acrylic resin and tested for load-to-failure using universal testing machine with cross head speed of 0.5mm/sec.

Results: The data obtained were tabulated and statistically analyzed using one way ANOVA and Student 't' test. The fracture pattern and failure modes were classified and analyzed with chi square test. The results of this study showed that the mean fracture load for group-MG is 2816.5N; group-MR is 2709N; group-CG is 679N; group-CR is 642.5N, with very high significant difference between metal and composite material and no significant difference between the luting agents among similar restorative material groups. Regarding the modes of failure, the maximum number of favorable fractures was observed in group-CG, group-CR and catastrophic failure among the metal endocrown groups.

Conclusion: Endo crowns fabricated with metal and luted with Glass ionomer cement exhibited superior fracture resistance and hence can be considered as a restorative option for ETT.

Key words: Post endodontic restorations; Post & core; Restoration of endodontically treated teeth

How to cite this article: *Seyed Asharaf Ali S, Suma Karthigeyan, ArunKumar E, Krishnaraj R, Kalarani G, Arun Priyadarshini. Fracture resistance of Endodontically treated teeth restored with Metal and Composite Endocrowns luted with two different luting agents: An in vitro study. J Clin Prosth Impl 2022;4(1):1-5.* ***https://doi.org/10.55995/j-cpi.2022001***

INTRODUCTION

An Endodontic therapy is considered to be complete only when the tooth is adequately restored. Aquilino and Caplan reported that endodontically treated teeth (ETT) without prosthetic restorations had 6 times higher failure rate than teeth restored with coronal coverage.[1] Traditionally full coverage crowns are the gold standards to restore ETT. But it requires extensive removal of circumferential tooth structure from an already weakened tooth. It was shown that an extensive tooth preparation leads to maximum tooth fragility.[2]

To overcome this problem, Bindl and Mörmann,[3] proposed the concept of "endocrown", based on a monobloc technique described by Pissis.[4] Endo-crown can be described as an onlay restoration engaging the pulp chamber with a supra-cervical butt joint, retaining maximum enamel for adhesion. The main objective is to reduce the extensive tooth preparation and achieve a bonded restoration that is minimally invasive to root canals.[5] In addition, the recent developments in adhesive bonding ensure predictable results with endocrowns making it more resistant to compressive forces than conventional crowns.[6]

Usually endocrowns are milled using computer-aided techniques or by molding ceramic materials under pressure.[5,7] But in many parts of the world, metal alloys and lab processed composites are still

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the restorative materials of choice. Moreover, adhesive cements are recommended for endocrowns,[5] Whereas glass ionomer cement (GIC) is the most frequently used cements in dentistry because of its well-known clinical characteristic and long history of effectiveness. So, the purpose of this study was to evaluate the fracture resistance of the ETT restored with 'Endocrowns' fabricated using metal and Lab Processed Composite resin, luted with adhesive resins and glass ionomer cement by a simple load-to-failure test. The null hypotheses of this study were as follows:

1. There would be no significant difference in the fracture resistance of ETT restored with composite and metal endocrowns
2. There would be no significant difference in the influence of the luting agents on fracture resistance of ETT restored with endocrowns.

MATERIALS AND METHOD

Forty freshly extracted maxillary premolars, free of defects and restorations were selected by measuring the buccolingual and mesio distal widths at the cementoenamel junction (CEJ), allowing 10% maximum deviation from the mean.[8] The occlusal portion of all premolars was reduced, made flat and perpendicular to the long axis of the tooth. A conservative access cavity, with Class-I cavity configuration was prepared using high speed air turbine hand-piece (Pana-Air, NSK) using round end diamond burs (Dia-burs, Mani Inc.,), with copious irrigation. The teeth were endodontically treated, obturated prior to tooth preparation.

The specimens were mounted in polyvinyl chloride (PVC) rings using auto-polymerizing acrylic resin (DPI Cold Cure, India), with the help of a surveyor (Ney surveyor). The crowns of the teeth remained free of the acrylic, and the root was covered to a height 2 mm below the CEJ, which is approximately the level of alveolar bone in a healthy tooth. For all the mounted specimens, endocrown tooth preparation was performed using high speed air turbine hand-piece (Pana-Air, NSK) with diamond burs. Preparations were limited to flat occlusal surface with butt joint (WR-13, Dia-burs, Mani Inc.,), removal of excessively retentive areas, and alignment of the pulpal walls with an internal taper of 8 to 10º (EX-24, Dia-burs, Mani Inc.,) and rounded internal line angles. The depth of the pulp chamber cavity is standardized to 5mm from cavosurface margin by reducing the height of the occlusal surface perpendicular to the long axis of the tooth. Finally, a smooth, continuous counter-bevel (TC-21, Dia-burs, Mani Inc.,) with 45º angulations was established on the external margins of the tooth. (*Fig 1*) Preparations were finished and polished, allowing a path of removal without interferences (*Fig 2*)

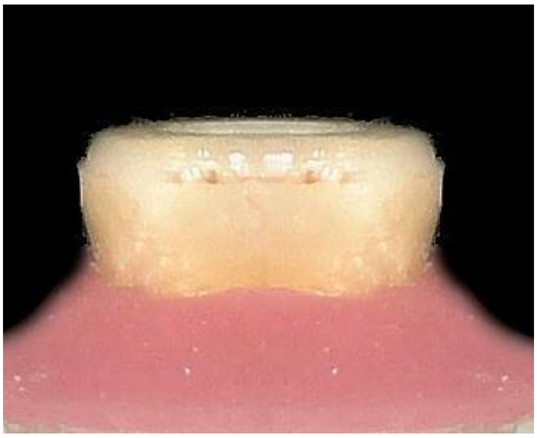

Fig 1: Proximal View of Finished Preparation

Fig 2: Occlusal View of Finished Preparation

The teeth were randomly distributed into four groups with 10 specimens on each group (n=10).

1.Group-MR: specimens restored with metal endocrowns and luted with resin cement;

2.Group-MG: specimens restored with metal endocrowns and luted with glass ionomer cement;

3.Group-CR: specimens restored with composite endocrowns and luted with resin luting cement;

4.Group-CG: specimens restored with composite endocrowns and luted with glass ionomer cement.

The metal and composite endocrown restorations with a standardised height of 2.5mm from the cervical side walk margin to the marginal ridge of the occlusal surface were fabricated by an experienced laboratory technician, following the manufactures instruction (*Fig 3*). Finally, the restorations were checked for fit with respected specimens. Prior to luting procedure, the intaglio surface of the metal and composite endocrown restorations were air borne particle abraded with 110µ Al2O3 at 60 psi pressure for metal endocrowns and 15 psi pressure for composite endocrowns and cleaned with ultrasonic cleaner. Finally, both the metal and composite endocrowns were stored in distilled water at room temperature until luted with appropriate cements.

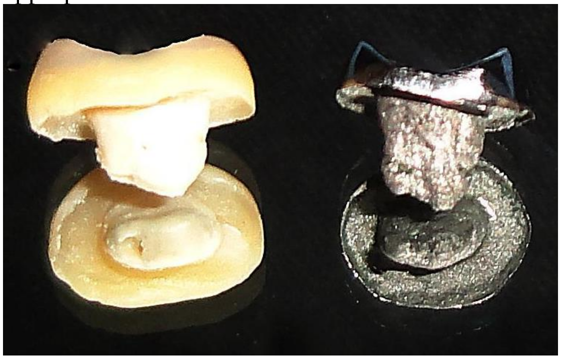

Fig 3: Mirror View of the Intaglio Surface of Composite Endocrown and Metal Endocrown

Among the forty specimens, twenty specimens (10 – metal endocrowns, 10 – composite endocrowns) were luted with self-adhesive, self-curing dental resin cement (Multilink® Speed, Ivoclar Vivadent) and the remaining twenty specimens (10 – metal endocrowns, 10 – composite endocrowns) were luted with radiopaque self-cure glass ionomer luting cement (Type-I GC gold label, GC corporation) as per manufacture's instruction. Finally, the specimens were verified for complete set of the luting cements and stored in normal saline at room temperature for 24-hours before testing.

All the specimens were subjected to simple, static, compressive load-to-failure test in an electromechanical universal testing machine (UNITEK 94100, FIE Group, India). The compressive load was applied parallel to the long axis of the tooth, on the inner cuspal slopes of the restorations with a metal rod of 5mm diameter as an antagonist, at a cross head speed of 0.5 mm/s. [8]

The fracture resistance values were tabulated in newton units and statistically analyzed using one-way ANOVA and student-'t' test (Paired-'t' test). The level of significance was set at $P < 0.05$. The characteristics of fracture for each specimen were classified according to the pattern6 shown in (*Table 1*). Chi-Square test ($\chi 2$) was used to compare the failure modes of specimens.

FRACTURE PATTERN		DESCRIPTION
Fracture of Endo crown		Fracture of the restoration alone
Fracture of tooth		Fracture of the tooth alone without any displacement (loss of adhesion) of the restoration
Fracture with displacement	Favorable	Fracture of the tooth with displacement of the restoration above CEJ (Restorable)
	Unfavorable	Fracture of the tooth with displacement of the restoration below CEJ (catastrophic/unrestorable)
Displacement without fracture		Displacement (loss of adhesion) of the Endo crown without fracture of the restoration or tooth
Intact samples		Survived samples without any fracture and displacement of both restoration and tooth. (Fracture of acrylic resin mount beyond maximum compressive force)

Table 1: Classification of Fracture Pattern

RESULTS

The mean fracture load required to fracture the specimens was maximum for group-MG, followed by group-MR, group-CG and minimum for group-CR. According to one-way ANOVA analysis, there was a very high significant difference in the mean fracture resistance among all groups (*Table 2*). However, the Student't'-test revealed that there is no significant differences between the groups restored with similar restorative material, i.e., between group-MR and MG (*Table 3*), between group-CR and CG (*Table 4*).Among the modes of fracture, the maximum number of favorable fractures was observed in group-CG and the minimum number was observed in group-CR (*Fig 4*). But 50% of the group-CR has undergone catastrophic failure. Almost 50% of the metal endocrowns irrespective of luting material remained intact without any fracture of either restoration or tooth. But, remaining 50% has undergone severe catastrophic failure (*Fig 5*). According to chi-square test, there was very high significant difference in the fracture mode of all groups (*Table 5*).

Fig 4: Fracture Pattern of CR (Left) &CG Group (Right)

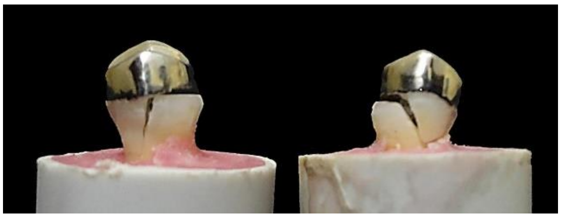

Fig 5: Fracture Pattern of Metal-Resin (Left) And Metal-GIC Group (Right)

Groups	Mean	Std. Deviation	F- Value	P- Value
Composite + Resin cement	642.50	220.94	49.91	0.001 (Significant)
Composite + GIC	679.00	183.12		
Metal + Resin cement	2709.00	698.51		
Metal + GIC	2816.50	782.08		

Table 2: Comparison of Fracture Resistance of All Groups

Groups	Mean	S.D	t- Value	P- Value
Metal+resin (MR)	2709.00	698.51	0.368	0.721 (Not Significant)
Metal+GIC (MG)	2816.50	782.08		

Table 3: Comparison of Fracture Resistance of Groups Restored with Metal Endocrowns

Groups	N	Mean	S.D	t- Value	P- Value
Composite+ resin (CR)	10	642.50	220.94	0.360	0.727 (Not Significant)
Composite+ GIC (CG)	10	679.00	183.12		

Table 4 - Comparison of Fracture Resistance of Groups Restored with Composite Endocrowns

Fracture Pattern		GROUP CR	GROUP CG	GROUP MR	GROUP MG	χ^2	df	P- value
Fracture of Endo crown		5	10	-	-	59.73	15	0.001 (Significant)
Fracture of tooth		-	-	-	-			
Fracture with displacement	Favorable (above CEJ)	-	-	-	-			
	Unfavorable (below CEJ)	5	-	3	7			
Displacement without fracture		-	-	-	-			
Intact samples		-	-	7	3			

Table 5- Comparison of Fracture Pattern of All Groups

DISCUSSION

The data in this study supports the rejection of first null hypothesis as the fracture strength of teeth restored with both composite and metal endocrowns are significantly different in a larger scale. The fracture strength of teeth with metal endocrowns (2762.75) was four times more than the composite endocrowns (660.75). This data, when compared with the fracture resistance of teeth with leucite endocrowns (1446.68N)[8] and lithium-di-silicate endocrowns (1107.3N)[9] shows that the fracture resistance of teeth with metal endocrown is superior among the documented endocrown materials.

The specimens with least fracture resistance in this study are the composite-resin (CR) groups with 660.75N. In the premolar region of healthy young adults, the normal biting force is 222−445N[8]; the maximum voluntary biting force (MVBF) is 422.93 ± 22.2N for male and 349.45 ± 24.1N for female[10]. This shows that, in spite of less fracture resistance, composite can be considered as a favorable endocrown material to withstand the normal - maximal bite forces.

When considering the influence of luting system, the resin bonded groups (Group-MR & CR) showed lower fracture resistance than the GIC luted groups (Group-MG & CG). But such reduction is not significantly different with similar crown material groups (MR Vs MG or CR Vs CG), validating the second null hypothesis of this study.

Mormann et al had demonstrated that a 2mm increase in the occlusal thickness, increased the fracture value significantly by 71% for cemented endocrowns and 21% for bonded endocrowns.[11] Also, Zarone et al[12] has reported that using the low modulus glass-ionomer cement to improve the stress adsorbing function of an alumina endocrown, does not reduce the stress arising in the system because of the high rigidity value of alumina. These studies thus substantiates that the endocrown material influenced the biomechanical behavior of the restored tooth regardless of the choice of luting cement.

Regarding the analysis of fracture pattern, the present study indicates that Group-CR yielded favorable strength but also led to unrestorable fractures compared to Group-CG, where all the fractures were limited to endocrown itself, leaving the tooth intact. On the other hand, all the metal endocrowns that were fractured are catastrophic in nature. This is in agreement with other studies revealing higher rates of unrestorable failures with strong, stiff materials or onlay-type restorations.[13] But it should be mentioned that the magnitude of force needed to fracture the teeth restored with metal endocrowns is much higher than all the clinical bite force values.

The fracture pattern in the CG-groups, where all the endocrowns fractured, leaving the underlying teeth intact may be due to the low bond strength of the Glass ionomer cement which always results in cohesive failure.[13]

Irrespective of the luting agent, the majority of failure modes in metal groups were in oblique direction. This implies that the fracture may be due to the wedging effect caused by the pulpal extension of the endocrown, because of the stiffness mismatch between tooth and restoration. This statement is in agreement with Zarone et al[12] who stated that the high stiffness materials significantly withstand deformation, but generate high stress concentrations at the interfaces, modifying the biomechanical behavior of the restorative system negatively. So, it can be summarized that the choice of endocrown material might not be critical when considering low to average bite forces but could ultimately influence the outcome at high-load catastrophic stress.

During tooth preparation, the earlier designs recommend a flat cavo-surface margin for all-ceramic endocrowns.[5] But in the present study, metal and laboratory processed composites are used as endocrown materials. So, a counter-bevel was provided on the axial-occlusal line angle to achieve better marginal adaptation of the margin configuration. In addition, the counter-bevel also increases the surface area of enamel and opens up the enamel rods for better bonding.

This study does not include thermocycling and fatigue loading of the specimens prior to load to failure test. However, within its limitations, this study provided sufficient data to substantiate the use of metal, composite as the endocrown material and glass ionomer as the luting agent.

CONCLUSION

Two Within the limitations, the following conclusion can be drawn from this in-vitro study:

1. Teeth restored with metal endocrowns have greater fracture resistance than all other restorative materials.
2. There is no significant difference between the influences of luting system, when compared with similar endocrown materials.
3. Teeth restored with composite endocrowns are adequate and favourable to withstand normal-maximum biting force.
4. There was significant difference between the fracture modes of all the four groups, with more favourable fracture in Composite-GIC (Cg) group followed by Composite-resin (Cr) group providing the chance of retreatment of the tooth.

CONFLICT OF INTEREST

There is no conflict of interest

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