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Comparative evaluation of the fracture resistance of endodontically treated teeth with different access designs

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Abstract

Background: Most important step for successful endodontic treatment is access cavity preparation. However, the removal of tooth structure needed for access cavity leads to compromise of pericervical dentin and remaining dentin thickness undermining the strength of tooth and increasing the root fracture propensity under functional loads. Therefore, in the present study fracture resistance of endodontically treated teeth with Traditional endodontic cavity [TEC] to Conservative endodontic cavity [CEC] and pericervical bonding of composite resin in different root filled teeth was evaluated by using Universal Testing Machine.

Materials and Methods: Freshly extracted single rooted premolars were selected and randomly divided into two groups:

Group 1: Traditional Endodontic Cavity (TEC) (n=24)

Group 2: Conservative endodontic cavity (CEC) (n=24)

Access cavity preparation and shaping cleaning followed by obturation was done according to the respective groups. The specimens were further subdivided into:

1. GROUP 1a: TEC restored with Cavit
2. GROUP 1b: TEC restored with nanocomposite
3. GROUP 2a: CEC restored with Cavit
4. GROUP 2b: CEC restored with nanocomposite
5. The specimens were then loaded to fracture in Instron Universal Testing machine and the fracture resistance data was further analysed and compared.

Results: The mean fracture strength for CEC restored with nanocomposite was significantly higher than all the other groups. (p<0.05)

Conclusion: Specimen with CEC showed better fracture resistance when compared with TEC. Pericervical bonding of composite resins contribute in increasing fracture strength for endodontically treated teeth.

Keywords: conservative endodontic cavity, traditional endodontic cavity, fracture strength, pericervical bonding, residual dentin thickness

1. Introduction

The preliminary step before the triad of endodontics is considered as the most crucial step in root canal treatment. That step is known as access cavity preparation. The traditional endodontic cavity design has been followed since years theoretically and clinically.

However, the removal of tooth structure needed for access cavity preparation may undermine the strength of the tooth to fracture under functional loads^[1]. Extraction is the most frequent consequence of fracture of endodontically treated teeth. Extended preparation of endodontic access cavities critically reduces the residual dentin thickness and increases the deformability of the tooth, compromising the strength to fracture of endodontically treated teeth^[2].

Therefore, in the recent years it has been seen in the literature that there is a paradigm shift coming into existence to a more conservative endodontic cavity. The aim of extension to prevention has now been modified with the introduction of 'Minimally Invasive Endodontics' as nature's blueprint cannot be recreated. The critical zone which is peri cervical dentin is considered most sacred and irreplaceable^[3,4].

Long-term retention of the tooth and resistance to fracturing are directly related to the amount of residual tooth structure. Hence, with the aim of preservation of PCD and to minimize tooth structure removal, conservative endodontic cavity (CEC) was reported in the literature [5, 6].

This minimally invasive endodontic cavity or CEC can only be applied when the following criteria are fulfilled. There should be direct visualisation of the entire floor of the pulp chamber and ability to fully explore the anatomy of the pulp chamber. The clinician should have an ability to localise all of the anticipated canal orifices. The endodontic cavity should facilitate complete removal of any present calcifications on the floor of the pulp chamber. The endodontic access cavity should allow exploration and cleaning of the pulp chamber without removing the pulp horns and with minimal removal of the roof [7, 8].

Thus, the aim of the study was to compare and evaluate fracture resistance of endodontically treated teeth with Traditional endodontic cavity [TEC] to Conservative endodontic cavity [CEC] and the pericervical bonding of composite resin in different root filled teeth.

2. Methodology

After the sample size estimation, 48 extracted intact single rooted premolars were selected for study. The specimens were screened radiographically to include teeth with completely formed apices. The exclusion criteria for the tested specimen were the presence of caries, previous restoration, and visible fracture lines or cracks. After a debridement with hand scaling instruments the teeth were stored in normal saline until used and during all the time between the different phases of the experiment in order to prevent their dehydration. Specimen preparation included acrylic embedding of all the teeth with a light bodied impression material to simulate the presence of PDL.

2.1 Access Cavity Preparation

The specimens were then divided into two groups of 24 teeth each according to the treatment protocol i.e.

Group I- Traditional Endodontic Cavity

Group II- Conservative Endodontic Cavity

The punch cut for tradition endodontic cavity was done by round bur no. 4. The cavity was extended with the help of an EndoZ bur in an oval shape. In the CEC group, premolars were accessed 1 mm buccal to the central fossa under 10x magnification, and cavities extended apically by EG burs, maintaining part of the chamber roof and lingual shelf.

2.2 Endodontic Treatment

Root canals were negotiated with size 10 K-type files to the major apical foramen, and canals were instrumented to length with Mtwo nickel titanium rotary instruments), with a 16-mm working part, up to the #25 tip size and 0.06 taper file. During endodontic treatment, 5.25% sodium hypochlorite and normal saline were intermittently used for irrigation, and after instrumentation, the root canals were irrigated with 17% EDTA solution. The final irrigation was done by normal saline. The canals were dried with paper points and filled with gutta-percha (single-cone size 25, 0.06 taper) and a resin-based endodontic sealer (AH Plus) Afterward, the teeth were subjected to postoperative radiographs.

2.3 Post Endodontic Restoration

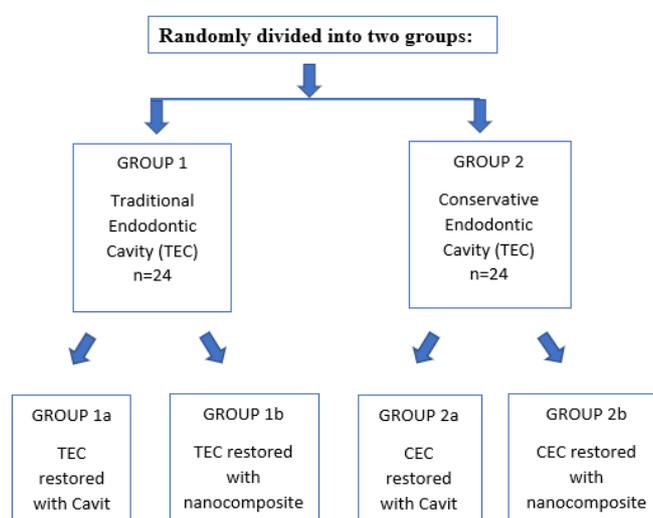
The gutta percha was seared off till CEJ level and the specimen were further subdivided into 2 groups based on the

restoration. Half of the specimen in traditional endodontic cavity and conservative endodontic cavity were etched with 37 % phosphoric acid followed by application of universal bonding agent and restoration by packable nanocomposite. The other half of the specimen in both the groups were restored with cavit G.

2.4 Fracture Strength Testing

All the specimens were then subjected under UNIVERSAL TESTING MACHINE. The specimens were loaded at their central fossa at a 30 degree angle from the long axis of the tooth. The continuous compressive force at a crosshead speed of 1 mm/min was applied using a 8-mm-diameter ball-ended steel compressive head. Specimens were fractured at different level of pericervical dentin under maximum compressive load which was indicated by the software of the universal testing machine and were recorded in newtons.

2.5 Study Design



3. Statistical Analysis

The data was analyzed with Statistical Package for Social Sciences (SPSS) for Windows 25.0 (SPSS, Inc. Chicago, Illinois). Confidence intervals were set at 95% and values of $p < 0.05$ were interpreted as statistically significant. Unpaired t test was applied to compare Traditional and Conservative access cavity preparation for GP obturated filled with cavIt and GP obturated canal bonded with composite resin.

4. Results

The mean and standard deviation of fracture strength of different access cavity was shown in table no. The results of this study showed that mean of CEC restored with composite resin (group 2b) shows maximum fracture strength of 1832.44 N followed by CEC restored by cavIt with 1426.53 N. Unrestorable fractures were significantly more frequent in the TEC and CEC. ($p < 0.05$)

5. Discussion

Endodontically treated teeth have often been at the risk of fracture and one of the most important cause is loss of tooth structure. The preparation of the endodontic access cavity following the TEC principals was reported as the second largest cause of loss of tooth structure [1, 2]. Moreover, removal of hard tissue increases cuspal deflection under occlusal load, and the number of remaining cavity walls influences the strength to fracture. Therefore, a proper and

reduced endodontic access design could improve the prognosis for an endodontically treated tooth [9].

TEC leads to overextension and gouging leading to compromise in peri cervical dentin and hence making teeth more fracture prone.^{10,3} Hence, CEC was introduced with an objective to increase fracture strength in endodontically treated teeth as compared to TEC as CEC is intended to preserve the pericervical dentin which in turns helps in long term retention teeth and resistance to fracture [6, 12].

Therefore, the aim of the present study was to compare and evaluate fracture resistance of endodontically treated teeth with Traditional endodontic cavity [TEC] to Conservative endodontic cavity [CEC] and the pericervical bonding of composite resin in different root filled teeth.

In the present study, single rooted premolar teeth were selected as specimen to avoid anatomical variation as seen in molars and other multirooted teeth. Selection of premolars can also be attributed to increased incidence of fracture as suggested by Plotino *et al* (2017) [2].

The tooth gets more prone to fracture due to cumulative loss of tooth structure because of caries, trauma, and treatment procedures. To restore fracture resistance in teeth, modern dentistry has shifted towards bonded restorative procedures.¹³⁻¹⁶ Since the modulus of elasticity of composite resin is close to that of dentin, restoring endodontic cavities with composite resin showed a minimal stress jump at the resin-dentin interface, reduced cuspal flexure, and lowered probability of coronal fracture as suggested by Soares PV (2008), Taha NA (2014) [13, 18-20]. Therefore, in the present study restoration of PCD was done by dentin bonded composite and its impacts on microstrain distribution and load to failure was studied.

In the current study, the methodology of testing used was universal testing machine (UTM) which was in accordance with various studies by Corsentino *et al.* (2018) [1], Huynh *et al.* (2018) [13]. A 30-degree inclination angle was used because teeth are most vulnerable to fracture when eccentric forces are applied, reaching the failure point at lower loads in comparison to other studies with axial fracture loads [21-23]. However, intraoral conditions are not accurately reflected in which failures occur mainly because of fatigue in invitro analyses where fracture loading methodology is used [1, 2, 24]

The results of the present study suggest that TEC presented lower fracture strength as compared to CEC which is in agreement with study by Plotino *et al.* (2017), Krishan R *et al* (2014) [2, 25]. This can be attributed to the preservation of residual tooth structure and PCD in CEC.

On the contrary, findings by Corsentino *et al.* (2018), Ozyurek T (2018) and Moore B (2016) suggests that no significant difference of fracture strength resistance was found between teeth prepared with a conservative endodontic cavity or a conventional one. These contradictory findings could be attributed to different methodologic designs including the type of teeth considered, the restoration used,

and also the kind of material used for restorative procedures and methodologic issues related to the design of the fracture test [1, 25, 16]

The results of the present study also states that root canal treated specimen in groups restored with composite resin showed greater fracture resistance than that restored with cavit in both traditional and conservative access cavity. This finding suggested that bonding of PCD reduced flexing or caused stiffening of cervical root dentin, which does not allow the functional loads to be concentrated at the apical which was in accordance to study by Huynh *et al.* (2018) [13, 16].

According to the results of the present study CEC showed better fracture strength than TEC, but there could be risks of iatrogenic errors and inefficient canal instrumentation as previously reported in a study by Krishnan *et al.* (2014) [25]. However, a study by Moore B (2016) [21] showed that CECs in maxillary molars did not appear to impact instrumentation efficacy [29].

The principles of ideal access cavity preparation allow complete removal of pulp tissue, debris, and necrotic materials. However, the smaller the access cavity, the higher the risk of bacterial contaminations and the possibility of missing some root canal orifices [30]

Therefore, it is important to acknowledge that the present study and the testing was performed under ideal laboratory conditions which cannot be expected in a clinical practice. Also, further studies should be encouraged with the inclusion of newly introduced minimally invasive rotary file systems which can help in preservation of residual dentin. The major limitations of the present study could be that under in-vivo conditions various variables such as, thermochemical factors, variations of magnitude, speed and directions of masticatory forces that are peculiar to individuals' oral environment, occlusion, wear-ability, long term durability would also be contributing factors.

Hence, further clinical studies are necessary to determine the efficacy of instrumentation, difficulties during endodontic procedures and long-term prognosis of endodontically treated maxillary and mandibular molars and premolars with CEC. The long-term clinical effect of composite resin bonding of PCD in root-filled teeth also requires further investigation.

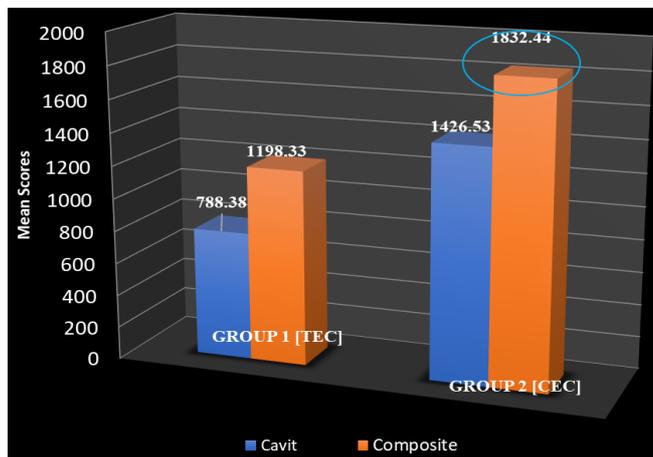
6. Conclusion

Within the limitations of present study, It can be concluded that:

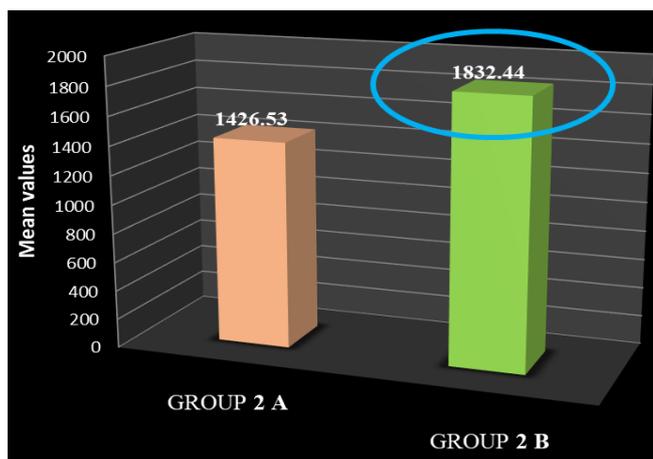
- Conservative endodontic cavity showed significantly higher fracture resistance than Traditional Endodontic Cavity.
- Pericervical bonding of composite resins contribute in increasing fracture strength for endodontically treated teeth.
- Conservative Endodontic cavity restored with composite resin after obturation showed highest fracture strength.

Table 1: Comparison of Fracture Strength in Groups. (Newton)

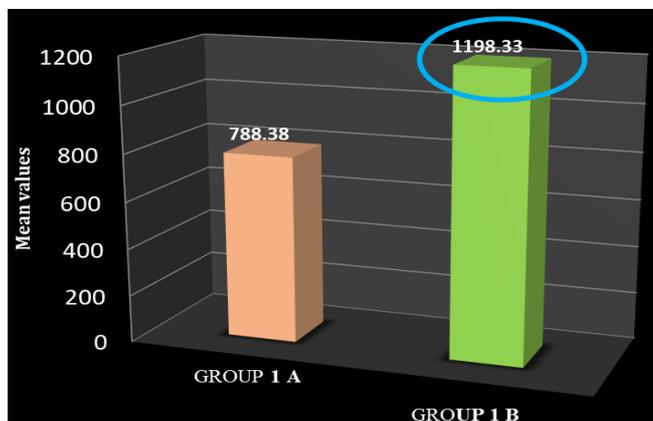
| | Groups | Mean | Std. Deviation | t-value | p-value | Significant |
|----------------|-----------|---------|----------------|---------|---------|-------------|
| Group 1 TEC | GROUP 1 A | 788.38 | 61.41 | -20.94 | 0.0001 | S |
| | GROUP 1 B | 1198.33 | 28.71 | | | |
| Group 2 CEC | GROUP 2 A | 1426.53 | 73.07 | -17.77 | 0.0001 | S |
| | GROUP 2 B | 1832.44 | 30.26 | | | |



Graph 1: Fracture strength



Graph 2: Fracture strength in conservation access cavity preparation



Graph 3: Fracture strength in traditional access cavity preparation



Fig 1: Traditional Endodontic Cavity

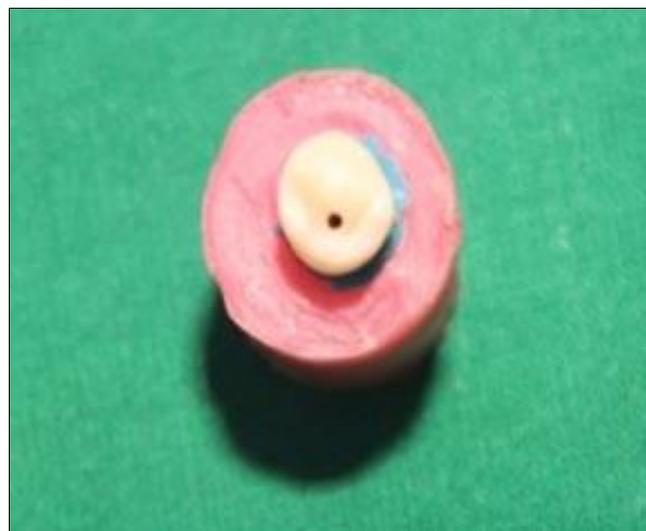


Fig 2: Conservative Endodontic Cavity

Materials and Methodology



Fig 3(a): Mtwo file system



Fig 3b: Materials for post-endo composite restoration

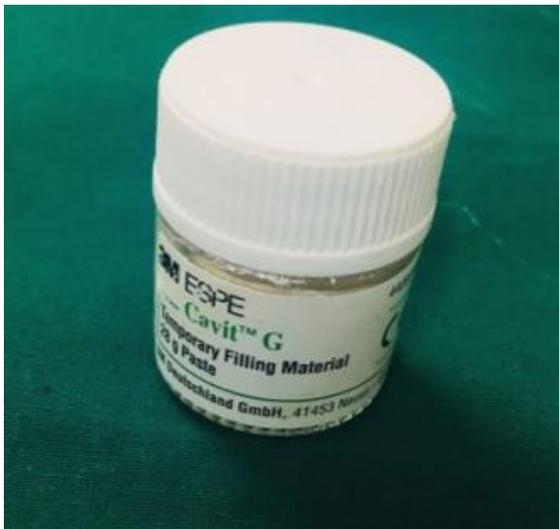


Fig 3c: Cavit G for post-endo restoration



Fig 5: Specimen places under UTM



Fig 4: Universal Testing Machine

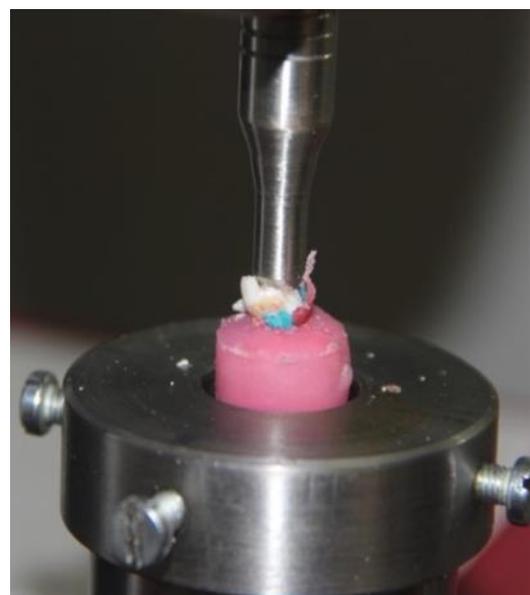


Fig 6: Fracture loading

Fracture of samples at different levels of pericervical dentin under maximum compressive load in universal testing machine



Fig 7a: Fractured specimen (sagittal view)



Fig 7b: fractured specimen (with root)



Fig 7c: Fractured specimen (close view)

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