Comparative Evaluation of Access Cavity Designs and Core Buildup Materials on Fracture Strength in Molars Using CBCT

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Abstract: ***Aim**: This study aims to evaluate the effects of traditional and conservative access cavity designs on the preservation of pericervical dentin thickness and fracture strength in root canal-treated molars with Class II caries, restored with conventional and fiber-reinforced composites. **Methodology**: After pre-operative CBCT, samples were divided into four groups based on cavity design and restored with different composites. The pericervical dentin thickness was evaluated. **Results**: Traditional access showed the highest reduction in dentin thickness and lowest fracture strength. **Conclusion**: Conservative cavity designs better preserve dentin and structural integrity than traditional designs, with fiber-reinforced composites not compensating for reduced strength.*

Keywords: Root canal treatment, CK access, Cone beam computed tomography, Fracture strength, Fiber reinforced composite, Pericervical dentin, Ninja access, Traditional access.

1. Introduction

Endodontically treated teeth are more susceptible to fracture than vital teeth. The traditional endodontic cavity (TEC) design has remained unchanged for decades, and only minor modifications have been done [1]. In TEC removal of excess tooth structure reduces the strength of the tooth leading to fracture under functional loads. Pericervical dentin is located 4mm coronal and 4mm apical to the crestal bone, and is crucial in transferring load from the occlusal table to the root [2]. Conservative endodontic cavity (CEC) preparation by Clark and Khademi (CK), minimizes tooth structure removal and preserves some of the chamber roof and pericervical dentin. An extreme conservative approach also has been proposed, which is known as ‘‘Ninja’’, were teeth are accessed in the same way as CK access, but the chamber roof is maintained as much as possible. This could be achieved with the help of Cone-beam computed tomographic (CBCT) imaging [3].These conservative techniques along with fiber reinforced composite reinforces the remaining tooth structure and is a good alternative for endodontically treated posterior teeth to improve the fracture strength [4]. This study evaluated and compared the effect of traditional and conservative access cavity designs in preserving the pericervical dentin thickness and also the fracture strength of traditionally and conservatively accessed RC treated molars with class II caries when restored with conventional and fiber reinforced composite. This study is significant as it provides insights into the impact of different cavity designs and materials on the structural integrity of endodontically treated teeth, which is crucial for clinical decision making.

2. Methodology

Thirty-two extracted permanent mandibular molars were collected. Preoperative CBCT scans (New Tom) were taken with 11 x 8 FOV by placing the teeth in wax on a plastic lower jaw model and the pericervical dentin thickness was evaluated at the cemento-enamel junction (Fig 1a). Mesial Class II cavity preparation was done in all groups except Group I with standardized dimensions of; width- 4 mm; height- 6 mm; depth- 2 mm (+/-0.5 mm) (Fig 1b).

Figure 1 (a) **Figure 1 (b)**
Figure 1 (a): Teeth embedded in wax
Figure 1 (b): Prepared Class II cavity

Samples were randomly divided into 4 groups (n = 8) depending on the type of access cavity preparation. Group I (Control Group- Unprepared teeth), Group II (Traditional access), Group III (CK access) and Group IV (Ninja access).

3. Sample Preparation

Group II
In TEC preparation, initial penetration was made using round bur (BR 41, Mani. Inc) in exact center of mesial pit of occlusal surface. The bur was directed toward the orifice of the mesiobuccal or distal canal, where the greatest space of pulp chamber exists. Once a drop was felt into the pulp chamber, working from inside out, back toward the mesial, the bur removed roof of the pulp chamber. An endodontic explorer was used to locate orifices of distal, mesiobuccal and mesiolingual canals. Final finish and funneling of cavity walls were completed with a fissure bur [1,5].(Fig 2a).

Group III

CK access was done using dental operating microscope (DOM) with Endoguide molarburs (SS White) preserving soffit and pericervical dentin [6]. Cavity was accessed at the mesial quarter of the central fossa, extended apically and distally while maintaining part of the chamber roof. Mesiodistal, buccolingual and circumferential pericervical dentin removal is minimized. Occlusal enamel was beveled at 45^0. The extension was not balanced equally between the buccal and palatal orifices but rather slightly favored the buccal orifice [7](Fig 2b).

Group IV
The 'ninja' access outline was derived from the oblique projection toward the center of the root canal orifices at the occlusal plane from CBCT. By doing this, localization of all the root canal orifices were possible but from different visual angulations [7] (Fig 2c).

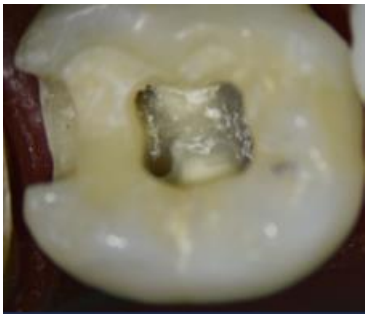

Figure 3 (a): Traditional access cavity

Figure 3 (b): CK Access cavity

Figure 3 (c): Ninja access cavity

Root Canal preparation and obturation
The root canals were scouted with #10 K file (Mani Inc., Japan) and checked for patency. Working length was determined radiographically and glide path was established up to the working length with a #20 K file. The instrumentation for all the groups (except group I) were done with ProTaper Gold (Dentsply Maillefer, Ballaigues, Switzerland) till F2 up to the working length. The canals were irrigated with 3% NaOCl and saline, in between each instrument, delivered by a 26-gauge needle, allowing for adequate back flow [8].

After access cavity preparation and cleaning and shaping, post operative CBCT scans were taken to evaluate pericervical dentin thickness at the cemento-enamel junction.

Canals were dried using paper points and obturated using single cone technique and sealed coronally using Conventional (Filtek™ P60 Posterior Restorative,3M ESPE) and Fiber reinforced composite (everXPosterior™, GC).

Restoration of the Samples
Except for the control group, all other groups where further divided into 2 subgroups (n=4). SUB-GROUPS IIA, IIIA and IVA restored with Fiber-reinforced composite and SUB-GROUPS IIB, IIIB and IVB restored with Conventional composite.

All the samples were etched for 15 seconds using 37% orthophosphoric acid, rinsed for 15 seconds, and then gently air dried. After this step, a self-etching adhesive was applied for 20 seconds, thinned with air, and then polymerized for 10 seconds using an LED device. For the samples in groups IIA, IIIA and IVA, Fiber reinforced composite (everXPosterior™, GC) and for the samples in groups IIB, IIIB and IVB Conventional composite (Filtek™ P60 Posterior Restorative,3M ESPE) were used as core buildup material, polymerized for 40 seconds using an LED light device. The occlusal anatomy of the samples were finished in accordance with that of the mandibular molar teeth.

Fracture Strength

The samples were coated with molten wax to 2 mm apical from the cemento-enamel junction and embedded in self-cure resin mold perpendicular to the ground plane. After completion of polymerization, the samples were removed from the resin mold. The molten wax was removed and replaced by silicon impression material to simulate periodontal ligament. The fracture strength was checked for all the groups by applying the force of 1 mm/min using "Universal Testing Machine" (Instron) until fracture and is calculated in Newtons (N) [6].

4. Results

Pericervical Dentin Thickness

On Evaluation of the pre-operative pericervical dentin thickness, no statistically significant difference was found in the mean pre pericervical dentin thickness between the groups in the buccal, lingual, and distal surfaces. Mesial pericervical dentine thickness could not be evaluated since class II mesio occlusal tooth preparation was done (Fig 3), (Table 1).

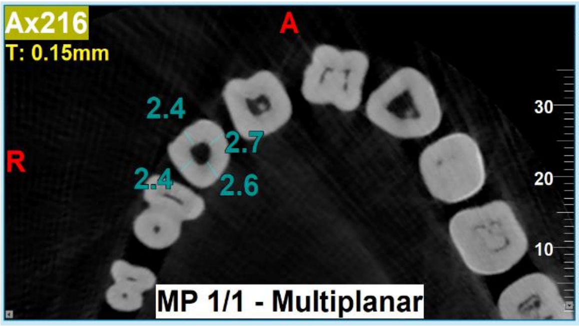

Figure 3: Measuring pericervical dentin thickness

Table 1: Comparison of difference in the pre and post pericervical thickness (mm) between the groups

Groups	Pericervical thickness (mm) Mean ± SD		
	Buccal	Lingual	Distal
Traditional	2.65 ± 0.22	2.62 ± 0.28	2.72 ± 0.26
CK Access	2.85 ± 0.26	2.61 ± 0.25	2.48 ± 0.33
Ninja Access	2.70 ± 0.43	2.42 ± 0.19	2.51 ± 0.35
P value	0.44	0.22	0.28

*One way ANOVA

The post peri cervical thickness in the buccal, lingual and distal surfaces were significantly lesser compared to pre peri cervical thickness within each group. (Table 2). On the buccal surface there is significant reduction in peri-cervical dentin thickness in all the groups. But on comparison between groups there is no significant difference in the reduction of peri-cervical dentin thickness among groups. (Table 3,4).

Table 2: Comparison of difference in the pre and post pericervical thickness (mm) between the groups in the Buccal surface

Groups	Difference in pericervical thickness (mm) Mean ± SD		
	Buccal	Lingual	Distal
Traditional	0.62 ± 0.48	0.95 ± 0.31	0.75 ± 0.18
CK Access	0.25 ± 0.11	0.35 ± 0.19	0.26 ± 0.10
Ninja Access	0.32 ± 0.13	0.32 ± 0.21	0.26 ± 0.18
p value	0.04	<0.001	<0.001

*One way ANOVA

Table 3: Post hoc analysis of difference in the pre and post pericervical thickness (mm) between the groups in the Buccal surface

Groups		Mean difference ± SE	p value*
Traditional	CK Access	0.37 ± 0.14	0.05
	Ninja Access	0.30 ± 0.14	0.13
CK Access	Ninja Access	0.07 ± 0.14	0.87

On lingual and distal surfaces there is significant reduction in peri-cervical dentin thickness in all the groups. Reduction in peri-cervical dentin thickness is highest in Group II followed by Group III and Group IV. The difference was significant between Group II and Group III as well as between Group II and Group IV, but there was no statistically significant difference between Group III and Group IV. (Table 4,5).

Table 4: Post hoc analysis of difference in the pre and post pericervical thickness (mm) between the groups in the lingual surface

Groups		Mean difference ± SE	p value*
Traditional	CK Access	0.60 ± 0.13	**<0.001**
	Ninja Access	0.62 ± 0.13	**<0.001**
CK Access	Ninja Access	0.02 ± 0.13	0.97

Table 5: Post hoc analysis of difference in the pre and post pericervical thickness (mm) between the groups in the distal surface

Groups		Mean difference ± SE	p value*
Traditional	CK Access	0.48 ± 0.09	**0.000178**
	Ninja Access	0.48 ± 0.09	**0.000178**
CK Access	Ninja Access	0.001 ± 0.09	1.00

Fracture Strength

On evaluation of the fracture strength, Group II (Sub groups IIA and IIB) showed significantly lower mean fracture strength compared to Group I, whereas Group III (Subgroups IIIA and IIIB) and Group IV (Sub-groups IVA and IVB) did not show any significant difference in mean fracture strength compared to Group I. Group II (Subgroups IIA and IIB) showed lower mean fracture strength compared to Group III and Group IV but this difference was not statistically significant. Group II (Subgroups IIA and IIB) showed significantly lower mean fracture strength compared to Group IV. There was no statistically significant difference in mean fracture strength between Group III & Group IV. There was no statistically significant difference between the Subgroups A & B in all the groups. (Table 6,7)

Table 6: Comparison of Fracture strength between the groups

Groups	Fracture strength (N) Mean ± SD	p value*
Control	3549.71 ± 237.3	**0.000088**
Traditional Fibre Reinforced	1978.75 ± 1003.9	
Traditional Composite	1840.71 ± 647.1	
CK Access Fibre Reinforced	2855.28 ± 667.3	
CK Access Composite	3054.90 ± 219.6	
Ninja Access Fibre Reinforced	3536.71 ± 308.7	
Ninja Access Composite	3309.62 ± 527.8	

*One way ANOVA

Table 7: Multiple comparison of Fracture strength between the groups

Groups		**Mean difference ± SE**	**p value***
Control	Traditional Fibre Reinforced	1570.96 ± 330.3	**0.001**
	Traditional Composite	1709.00 ± 330.3	**0.000423**
	CK Access Fibre Reinforced	694.42 ± 330.3	0.38
	CK Access Composite	494.81 ± 330.3	0.74
	Ninja Access Fibre Reinforced	13.00 ± 330.3	1.00
	Ninja Access Composite	240.09 ± 330.3	0.99
Traditional Fibre Reinforced	Traditional Composite	138.03 ± 381.5	1.000
	CK Access Fibre Reinforced	-876.53 ± 381.5	0.28
	CK Access Composite	-1076.14 ± 381.5	0.11
	Ninja Access Fibre Reinforced	-1557.95 ± 381.5	**0.006**
	Ninja Access Composite	-1330.86 ± 381.5	**0.02**
Traditional Composite	CK Access Fibre Reinforced	-1014.57 ± 381.50	0.15
	CK Access Composite	-1214.18 ± 381.50	0.05
	Ninja Access Fibre Reinforced	-1695.99 ± 381.50	**0.003**
	Ninja Access Composite	-1468.90 ± 381.50	**0.01**
CK Access Fibre Reinforced	CK Access Composite	-199.61 ± 381.50	0.99
	Ninja Access Fibre Reinforced	-681.42 ± 381.50	0.56
	Ninja Access Composite	-454.33 ± 381.50	0.89
CK Access Composite	Ninja Access Fibre Reinforced	-481.81 ± 381.50	0.86
	Ninja Access Composite	-254.71 ± 381.50	0.99
Ninja Access Fibre Reinforced	Ninja Access Composite	227.09 ± 381.50	0.99

*Post hoc Tukey's test

5. Discussion

Class II caries extending to the pulp is one of the common reasons for tooth to undergo endodontic treatment. Studies have reported that 46 % decrease in tooth strength is due to the loss of marginal ridge integrity [9]. Considering the increased incidence of class II carious teeth that is indicated for endo treatment and its vulnerability for fracture, class II cavity prepared teeth were used for this study.

Studies have reported that fracture of endodontically treated teeth is associated with loss of tooth structure due to dentinal caries, access preparation and root canal preparation [3]. Endodontic access cavity preparation increases cuspal deflection during function and decreased the fracture strength of teeth.

According to Clark and Khademi (2010) failures of endodontically treated teeth occur not just because of chronic or acute apical lesions, but also because of structural compromise to the teeth that render them weak [6]. Traditional endodontic access has primarily focused on operator needs, and is decoupled from the restorative needs and tooth needs [6]. For an ideal preparation, balance of these three factors should be followed for better outcome and long-lasting result.

The aim of this study was to compare the fracture strength of mandibular molars with different access cavity preparations. Newer conservative access cavity designs like CK access, Ninja access, Truss access are all aimed at preserving the maximum tooth structure possible.

The pre and post pericervical dentine thickness at the level of CEJ was assessed with the help of CBCT. CBCT was selected for this study as it provides small field of view images at low dose for endodontic diagnosis and was used by Makati et al for accurate assessment of PCDT [10].

Results of the present study showed that there is significant reduction in PCDT in all the groups. Maximum loss of PCDT was seen in traditional access cavity preparation followed by CK followed by Ninja access. There was no significant difference between CK and Ninja. This result is in accordance with studies done by Clark & Khademi as well as Varghese et al. Mishra A et al compared Ninja Access, Truss Access and CK Access in preservation of pericervical dentin thickness and found that Ninja access preparation technique is the most conservative technique of cavity preparation with least loss of dentinal volume in peri cervical area followed by CK preparation [11].

In this study, the CK and Ninja access cavity preparations resulted in significantly higher fracture strength values compared to the control and TEC groups, may be due to preservation of dentine, particularly in the pericervical area. The CK group used Endoguide burs under Dental operating Microscope and Ninja group used CBCT derived projection toward the center of the root canal orifices for access cavity preparation. Both these techniques allowed for better visualization and preservation of the pericervical dentin, thereby maintaining the structural integrity of the tooth.

Fracture strength of traditional access cavity group was significantly low compared to unprepared teeth. But in CK and Ninja access there was no significant reduction in fracture strength compared to unprepared teeth. That shows reduction in fracture strength is in proportion to the reduction in PCDT. This proves the importance of preservation of PCDT. This is in line with earlier study by Krishan R et al (2014) [12].

The current study also evaluated and compared the fracture strength of traditionally and conservatively accessed root canal treated molars with class II caries when restored with conventional and fiber-reinforced composite. There was no statistically significant difference between both in all the groups.

Results of this study contradicted the earlier studies by Vaishnavi et al and Neslihan et al [13,14]. Shiva et al in her study found that, EverX-Posterior used for large posterior restorations, improved both mechanical and physical properties[5]. Özyürek et al compared fracture strengths of mandibular molar teeth prepared using traditional (TEC) and conservative endodontic cavity (CEC) methods, and thereafter restored using SDR (Dentsply Caulk, Milford, DE) and EverX Posterior composite materials and concluded that SDR bulk-fill composite group had higher fracture strength than those restored with EverX Posterior [8]. In a study of comparison of fracture strengths of EverX Posterior and traditional composites, Frater et al reported that the best strength was obtained when the former was applied in oblique layers. In the present study, the fracture strength of EverX Posterior may have decreased because of the bulk filling application method employed [15].

From this study, it can be concluded that preservation of PCDT is very important in preventing fracture of endodontically treated teeth and attempts to compensate for lost tooth structure using improved restorative materials like Fiber reinforced composites does not contribute to improved fracture resistance.

6. Conclusion

Within the limitations of this study, it can be concluded that the CK and Ninja access cavity preparations can result in greater pericervical dentin thickness and higher fracture strength values compared to traditional access cavity preparations. Also, use of fiber reinforced composite for post endodontic restoration will not compensate for reduced fracture strength caused by loss of PCDT. Preservation of pericervical dentin is important for maintaining structural integrity of the tooth, and therefore these conservative techniques may be recommended for endodontic treatment

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