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EFFECT OF DIFFERENT ACCESS CAVITY DESIGNS ON THE CLEANLINESS OF ROOT CANAL SYSTEM IN ENDODONTICALLY TREATED TEETH (AN IN-VITRO STUDY)

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ABSTRACT

Objevtive: To evaluate the cleanliness of the root canal system after endodontic treatment of teeth with 4 different access cavity designs: Traditional, conservative, ninja and truss endodontic access cavity designs in terms of amount of debris and smear layer. **Material and Methods:** Sixty freshly extracted mandibular molars with moderate mesial root curvature were collected. Sample size used in this study was 60 mandibular molars, (n=120). They were divided into four groups (n=30), Group 1: Traditional endodontic access cavity (TEC), Group 2: Conservative endodontic access cavity (CEC), Group 3: Ninja endodontic access cavity (NEC), and Group 4: Truss endodontic access cavity (TREC). All canals were instrumented and prepared for scanning electron microscope evaluation (SEM). SEM images were taken x500 and x1500 for debris and smear layer evaluation in three areas of the root canal. Scoring system was proposed by Hülsmann et al (1997).[26] After data collection, data were presented in terms of mean ± SD using Minitab 19 program. **Results:** In terms of remaining debris, no significant difference was found in all groups. In terms of remaining smear layer, there was a significant difference between values in TEC, TREC and NEC. **Conclusion:** Within the limitation of this study, we can conclude that, access cavity design had no effect on root canal cleanliness at different canal levels.

KEYWORDS: Access cavity. Cleanliness. Scanning electron microscope. Debris. Smear layer.

INTRODUCTION

Proper access cavity and root canals location are important for a successful prognosis. An access cavity is defined as the opening in a tooth to enter the root canal system to enable cleaning, shaping and obturating.[1] The anatomy of the pulp chamber dictates the outline of the access cavity.[2-5] The aim of an access opening to be considered are as follows, removal of entire roof of pulp chamber, creation of tapered cavity walls, creation of a smooth pathway for instruments to canal orifices, and preservation of natural tooth substance.[6]

Traditional endodontic access cavity design (TEC) is a straight-line access to the root canal system. It allows the complete deroofing of the pulp chamber leading to sufficient debridement of the coronal portion of root canal system.[7] In the recent years, Clark and Khademi[8] modified the access cavity design known as conservative access cavity design. Here, the pulp chamber roof and pericervical dentin was preserved. Preparation of the soffit and ferrule helps in tooth retention and fracture resistance.[9] However, iatrogenic errors are possible due to lack of clinical judement.[10] According to Plotino et al[11], ninja access cavity design (NEC) started out as conservative access cavity design (CEC) without further extension. The pulp chamber roof and pericervical dentin is maintained. Some authors reported that this approach improved fracture resistance, hence, complex restoration is not necessary.[11,12] Another approach of CEC is the truss access cavity design (TEC). Here, separate cavities are prepared mesial and distal canal systems in mandibular molar leaving a truss of dentin between the two cavities.[13] One of the major drawbacks in such design is the possibility of clinical errors.[8] It remains verified if such designs hold significant advantage over TEC's in clinical situation.

The fracture resistance is reduced after root canal treatment due to alteration of dentin hardness.[14,15] Previous studies reported influence of size of access cavity on fracture resistance.[16,17] The preservation of roof chamber and pericervical dentin greatly influences fracture resistance. Many studies were made on the effect of contracted access cavity design on instrumentation efficacy. The TEC enhances instrumentation efficacy.[8,18,19] Neelakantan P et al[13] reported that the type of access cavity design did not influence the amount of remaining pulp tissue.

Various studies compared the effect of different access cavity designs on the fracture resistance of tooth structure. However, little studies were made to assess the cleanliness of root canal. Therefore, evaluation of the effect of different access cavity design on root canal cleanliness was thought to be of value. The null hypothesis was that there is no significant difference between traditional access cavity design and conservative access cavity designs in cleanliness of root canal space during endodontic treatment.

MATERIAL AND METHODS

Sixty freshly extracted mandibular molars with moderate mesial root curvature (20-40°) were collected from the outpatient clinic of Oral Surgery department *Faculty of Dentistry, Ain Shams University*. Standardized digital pre-operative Radiographs were taken before preparation. Schneider's method[20] was used to calculate the angle of curvature for both mesial canals.

Sample size used in this study was based on number of mesial root canals of 60 mandibular molars, (n=120). They were divided into four groups according to the access cavity design (n=30): Group 1: Traditional endodontic access cavity, Group 2: Conservative endodontic access cavity, Group 3: Ninja endodontic access cavity, and Group 4: Truss endodontic access cavity.

Access Cavity Preparation

1. Traditional Endodontic Access Cavity

Traditional access cavity was first described by Crane [21]in 1920. He stated that coronal cavity was to be shaped to allow free access to each canal. Jhon Ingle [22]in 1965 adapted the concept of cavity preparation from GV Black in 1908.[23] The most important points of cavity preparation are the convenience form and extension for prevention.[23] The convenience form is established by removing all intervening dentin to allow direct access to apical foramen. The extension for prevention focuses on enlarging the root canal to prevent complications.[22] Access preparation were done using a high-speed diamond stone. During access cavity preparation, the center of the pulp chamber was the target of the initial preparation, at a point where the roof and floor of the pulp chamber are at the widest. The outline form was then determined by the shape of the pulp chamber which also determines the occlusal extent of the cavity. A non-cutting bur Endo-Z (Dentsply Maillfer Instruments, Ballaigues, Switzerland) was used to remove the entire roof of the pulp chamber. The walls were then probed to ensure absence of any dentin ledges. The canal orifices were revealed by changes in dentin floor color.[19]

2. *Conservative Endodontic Access Cavity*

Clark and Khademi[8] proposed the conservative access cavity design where the pulp chamber roof and pericervical dentin was maintained. The teeth were accessed at the central fossa (mesial quarter) and extended distally and apically until all canals were located. Peri-cervical dentin removal mesiodistally, buccolingually, and circumferentially was minimized ensuring pulp chamber roof was partially maintained. All root canal orifices could be located visually from the same angulation. The preservation of this dentin above the pulp chamber is known as the "soffit". The peri cervical dentin is located 4mm above and 4mm below the crestal bone. They serve in distribution of functional stresses in teeth.[8]

3. *Ninja Endodontic Access Cavity*

Plotino at al[11] established the ultraconservative access cavity design in 2017, here, the access cavity is similar to the CEC without further extensions, also maintaining pulp chamber roof as much as possible. An oblique projection was made towards the central fossa of the root orifices in an occlusal plane. As the endodontic access is parallel with the enamel cut of 90° or more to the occlusal plane, it was easier to locate root canal orifices even from different visual angulations.[17-19]

4. *Truss Endodontic Access Cavity*

Neelakantan et al[13] made a study on mandibular molars in 2018 where a dentinal bridge was preserved between two or more small cavities to access the canal orifice(s). Truss endodontic access cavity is an orifice-directed design by preserving part of the pulp chamber roof. A periodontal probe was used to measure the distance from the marginal ridges and the buccal and lingual surfaces to the pulp chamber floor on radiographs. The margins were extended to the occlusal surface to serve as a guide for straight introduction of bur in to the canal orifices. Next, separate round access cavities were created for accessing the mesial canals in buccal and lingual directions. Another round access cavity was created to access the orifice of the distal canal. The separate round mesial access cavities were then merged to form an oval-shaped access cavity with a minimum diameter of 1.2mm. The round access cavity of the distal canal was flared while preserving its round shape to reach 1.2 mm diameter (measured by a caliber). The mesial and distal access cavities on the occlusal surface had been separated by a dentin-enamel bridge.[25]

Root Canal Preparation

All canals were instrumented to a size 25/0.06 taper using M-Pro rotary files (Guandong, China, Mainland) following manufacturer's instructions. Final master apical file was reached up to size #35/0.02 taper using manual K-file (Mani, Tchijo, Japan). During instrumentation, 5mL of 2.5% sodium hypochlorite (NaOCl) was delivered between each instrument. A size #10 K-file was used to maintain apical patency. After instrumentation each canal received a final rinse with 5 mL 2.5% NaOCl per canal at a flow rate of 2.5mL/ min. Canals were then irrigated with 3 mL saline before drying with absorbent paper points.

All samples were decoronated at a level of the cementoenamel junction. The mesial roots were then split longitudinally to be evaluated under SEM. SEM images were taken at 500x and x1500 magnification in three areas of root canal- coronal, middle and apical third for remaining debris and smear layer proposed by Hülsmann et al (1997)[26] **(Table 1 and 2).**

Table 1: The scoring system for remaining debris.

Score 1	Clean root canal wall, only a few small debris particles
Score 2	Few small agglomerations of debris
Score 3	Many agglomerations of debris covering <50% of the root canal wall covered by debris
Score 4	>50% of the root canal wall covered by debris
Score 5	Complete or nearly complete root canal wall covered by debris

Table 2: The scoring system for remaining smear layer.

Score 1	No smear layer, orifices of the dentinal tubules patent.
Score 2	A small amount of smear layer, some dentinal tubules open
Score 3	Homogenous smear layer along almost the entire canal wall, only very few dentinal tubules open.
Score 4	Entire root canal wall covered with a homogenous smear layer, no open dentinal tubules.
Score 5	A thick homogenous smear layer covering the entire root canal wall.

RESULTS

After data collection, data were presented in terms of mean ± SD using Minitab 19 program. One-way analysis of variance (ANOVA), and Tukey Honestly Significant Difference (HSD) test were calculated to determine any statistical difference amongst groups. In the present study, $P \leq 0.05$ was considered as the level of significance.

At the coronal third, there was no significant difference in values of remaining debris in different groups (p=0.593). At the middle third, there was no significant difference in values of remaining debris in different groups (p=0.965). At the apical third, there was no significant difference in values of remaining debris in different groups (p=0.165). The highest value of remaining debris was found in apical third of ninja access cavity design. The lowest value was found in coronal third of conservative access cavity design **(Table 3)**.

At the coronal third, there was no significant difference between values (p=0.456). At the middle third, there was no significant difference between values (p=0.21). At the apical third, there was no significant difference between values (p= 0.689). Regarding traditional access design, there was a significant difference between values (p=0.002). Regarding truss access design, there was a significant difference between values (p=0.028). Regarding ninja access design, there was a significant difference between values (p=0.027). The highest values of remaining smear layer were found in apical third of ninja and truss access cavity designs. The lowest values were found in coronal and middle thirds of traditional access cavity **(Table 4)**.

Table 3: Effect of different access cavity designs on remaining debris in different canal levels.

	Traditional	Conservative	Truss	Ninja	P-Value
Coronal	3.333 ±1.303 ^{a}	4.1 ±1.287 ^{a}	3.7 ±1.494 ^{a}	4 ±1.604 ^{a}	0.593 ns
Middle	4 ±0.853 ^{a}	3.9 ±1.595 ^{a}	3.7 ±1.418 ^{a}	3.889 ±1.537 ^{a}	0.965 ns
Apical	4.33 ±0.888 ^{a}	3.3 ±1.889 ^{a}	3.9 ±0.738 ^{a}	4.375 ±0.744 ^{a}	0.165 ns
P-Value	0.069 ns	0.174 ns	0.92 ns	0.751 ns	

Means that do not share same small letter in the same row are significantly different.
Means that do not share same small letter in the same column are significantly different.
s-significant (p≤0.05), ns-non-significant (p>0.05)

Table 4: Effect of different access cavity designs on remaining smear layer in different canal levels.

	Traditional	Conservative	Truss	Ninja	P-Value
Coronal	3.5 ±1.243 ^{a}	3.8 ±1.317 ^{a}	4.3 ±0.675 ^{a}	3.875 ±1.245 ^{a}	0.456ns
Middle	3.5 ±1.243 ^{a}	4.6 ±0.966 ^{a}	4.5 ±0.707 ^{a,b}	4.625 ±0.518 ^{a,b}	0.21ns
Apical	4.9167±0.2887 ^{b}	4.9167 ±0.2887 ^{a}	5 ±0 ^{b}	5 ±0 ^{b}	0.689ns
P-Value	0.002sig.	0.170ns	0.028sig.	0.027sig.	

Means that do not share same small letter in the same row are significantly different.
Means that do not share same small letter in the same column are significantly different.
s-significant (p≤0.05), ns- non-significant (p>0.05

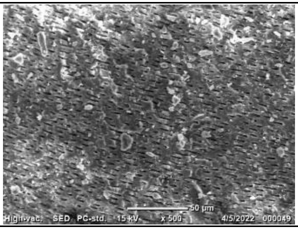
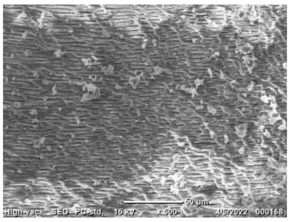
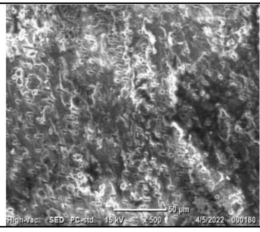
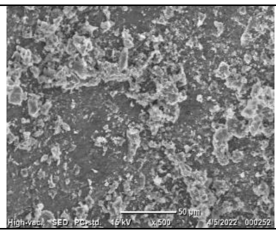
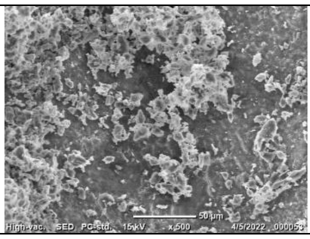
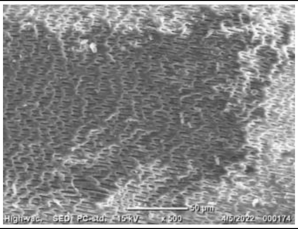
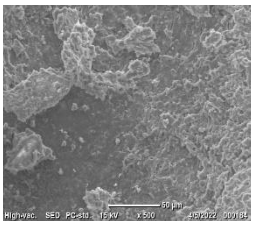
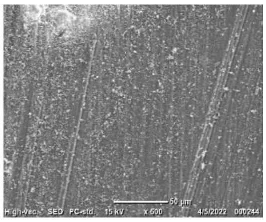
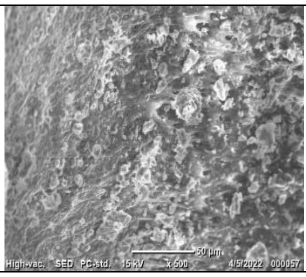
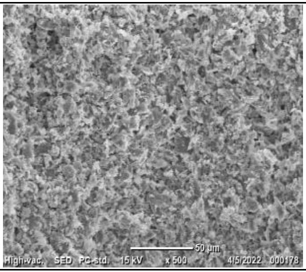
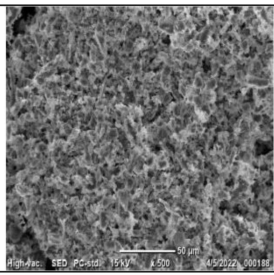
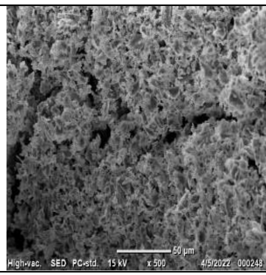
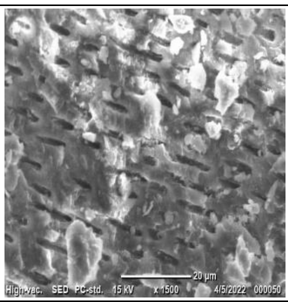
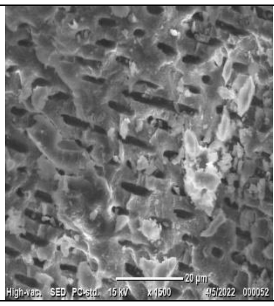
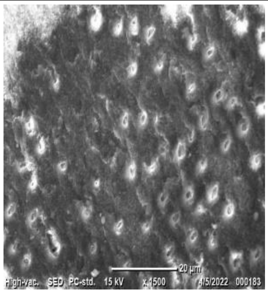
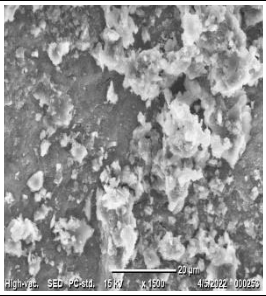
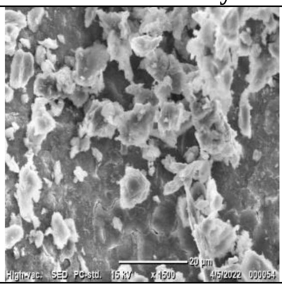
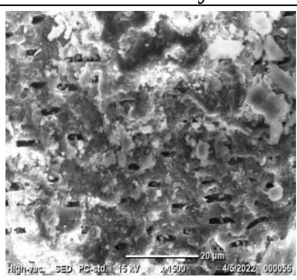
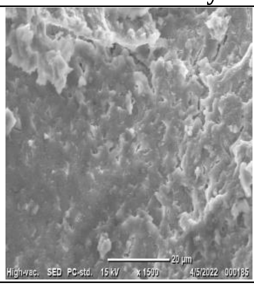
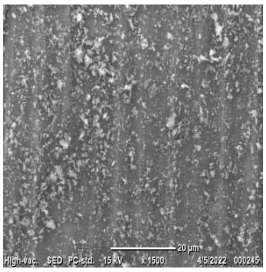
	A TEC	B CEC	C TREC	D NEC
Coronal third				
	Score 2 of Hülsmann scale for debris.	**Score 2 of Hülsmann scale for debris.**	**Score 3 of Hülsmann scale for debris.**	**Score 5 of Hülsmann scale for debris.**
Middle third				
	Score 4 of Hülsmann scale for debris.	**Score 3 of Hülsmann scale for debris.**	**Score 4 of Hülsmann scale for debris.**	**Score 4 of Hülsmann scale for debris.**
Apical third				
	Score 5 of Hülsmann scale for debris.	**Score 5 of Hülsmann scale for debris.**	**Score 5 of Hülsmann scale for debris.**	**Score 5 of Hülsmann scale for debris.**

Fig. 1 SEM images of magnification 500x showing remaining debris in mesial canals of a TEC; b CEC; c TREC and; d NEC.

	A TEC	B CEC	C TREC	D NEC
Coronal third				
	Score 2 of Hülsmann scale for smear layer.	**Score 2 of Hülsmann scale for smear layer.**	**Score 3 of Hülsmann scale for smear layer.**	**Score 5 of Hülsmann scale for smear layer.**
Middle third				
	Score 3 of Hülsmann scale for smear layer.	**Score 3 of Hülsmann scale for smear layer.**	**Score 4 of Hülsmann scale for smear layer.**	**Score 4 of Hülsmann scale for smear layer.**

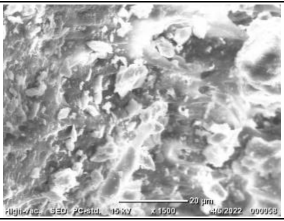
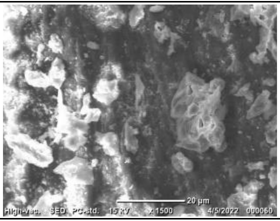
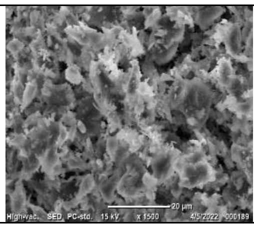
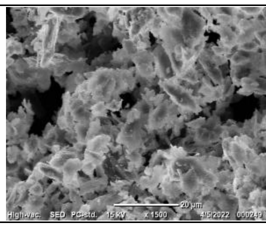
Apical third				
	Score 5 of Hülsmann scale for smear layer.	**Score 5 of Hülsmann scale for smear layer.**	**Score 5 of Hülsmann scale for smear layer.**	**Score 5 of Hülsmann scale for smear layer.**

Fig. 2 SEM images of magnification 1500x showing remaining smear layer in mesial canals of a TEC; b CEC; c TREC and; d NEC.

DISCUSSION

There is little evidence in the literature to accept or refuse the philosophy of minimally invasive access cavity designs based on the cleaning ability of the instrumentation process. The need to adequately clean the root canals remains an overarching objective for non-surgical root canal treatment.[10] The importance of minimally invasive access cavity designs is to conserve tooth structure to improve the prognosis of an endodontically treated tooth. However, smear layer and debris interfere with optimum canal cleaning and disinfection. The conservative design was generally modelled by Clark and Khademi.[8] They were known to conserve coronal dentin in teeth, and increase resistance to fracture. However, it is argued that such endodontic cavities may lead to operative difficulties during canal shaping, with coronal interferences having potential to cause root canal transportation.[28]

Human extracted teeth were used to stimulate the clinical situation. In this study, mesial roots of mandibular molars with a moderate curvature of (20^0-40^0) were selected because these roots contain canals that are often narrow and curved increasing difficulty of instrumentation.[20,29]

Direct digital radiography was used for evaluating the angle of curvatures of the samples. The angle of curvature was measured using Schneider's method.[20] This method is accurate, reliable and has been used by many authors.[30]

Concerning canal cleanliness, the results showed that there was no statistically significant difference between the four different access cavity designs in the percentage of debris, and smear layer at each level of the canals (apical, middle, and coronal thirds). Our Study agreed with Rover G et al (2017)[27] where he stated that accumulation of debris has occurred regardless of endodontic access cavity design. Neelaktan P et al (2018)[13] also reported that the amount of debris in apical, middle, and coronal thirds was similar in truss and traditional endodontic access cavity.

Our results disagreed with Vieira et al (2020)[31] who reported that disinfection was significantly compromised after root canal preparation of minimally invasive access cavity in mandibular incisors. Silva et al (2020)[32] also reported high debris accumulation in ultraconservative access cavities in mandibular premolars. This might be due to the use of distinct teeth, root canal preparation and design of access cavities. Barbosa et al (2020)[33] reported that truss access design offered better results than conservative design in microbial and hard tissue debris reduction.

The highest values of remaining debris and smear layer were usually found in apical thirds of root canals. Lateral canals and apical ramifications are most commonly present in apical third of the root which also may be one of the reasons of highest debris values in apical third.[34] This is in agreement with Raut et al (2016)[35] who reported that apical third was less clean than middle and coronal third regardless instrument used.[13]

CONCLUSION

Within the limitation of this study, we can conclude that, access cavity design had no effect on root canal cleanliness at different canal levels. Regardless to the access cavity design, complete removal of smear layer and debris is impossible. The design of access cavity doesn't influence the cleanliness of root canal in terms of debris and smear layer. The highest amount of debris and smear layer is present in the apical third.

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