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EVALUATION OF DEBRIS COVERING THE PULP CHAMBER AND ROOT CANALS AFTER IRRIGANT ACTIVATION USING DIFFERENT ACCESS CAVITY DESIGNS

Ahmed Mohamed M. M. Ismail[1*], Amr Abd-El Wahab Bayoumi[2], Moataz- Bellah A.M. Alkhawas[3]

ABSTRACT

Objectives: This study aimed to evaluate the cleanliness of the pulp chamber and root canal after irrigant activation using different access cavity designs. **Materials and methods:** 60 human lower mandibular first molars were divided according to access cavity design into three main groups(n=20): guided conservative access cavity design (GCAC), truss access cavity design (TAC), and conservative access cavity design (CAC); each group was further subdivided into two subgroups(n=10): side-vented irrigating needle(A) and Endovac activation system (B). A Pre-operative Cone beam computed tomography (CBCT) was done for all samples. After chemo-mechanical preparation for all samples, samples were sectioned and scanned by scanning electron microscope (SEM) at 500 X to evaluate the remaining debris covering the pulp chamber and mesiobuccal root canals. **Results:** TAC showed a significant difference from CAC and GCAC. No difference between CAC and GCAC. **Conclusion:** TAC is an ultra-conservative access cavity design but compromises root canal system cleanliness.

KEYWORDS: Access cavity, Debris, Cleanliness, Endovac, SEM

INTRODUCTION

Successful endodontic treatment requires appropriate access cavity preparation, adequate cleaning and shaping, and a complete three-dimensional obturation (1). The access cavity is the first step in root canal treatment (2). Several designs of endodontic access cavities have been proposed to minimize tooth structure loss, thus theoretically increasing the mechanical stability and fracture resistance of root-filled teeth (3).

The extension of the prepared cavity may decrease the strength of the tooth to fracture under functional load (4). A new design of access cavity is conservative endodontic access (5). It is a small conservative cavity that allows the clinician to access all the canal orifices, minimize the tooth structure removal, and preserve some of the chamber roof and the peri-cervical dentin (3).

Another form of more conservative access cavity designs, as truss endodontic access, is direct access from the occlusal surface to expose the mesial and distal Canal orifices while leaving the intervening dentin intact (6). Maintaining the marginal ridge integrity and width of the isthmus region may be necessary to reduce tooth fracture (7).

1. Masters Candidate, Endodontic Department, Faculty of Dental Medicine, Boys, Cairo Al Azhar University.
2. Lecturer, Endodontic Department, Faculty of Dental Medicine, Boys, Cairo Al Azhar University.
3. Professor and head of Endodontic Department, Faculty of Dental Medicine, Boys, Cairo Al Azhar University

• ***Corresponding author*:** a7med.isma3il@hotmail.com

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The most recent technique in access cavity preparation is guided endodontic access [8]. The development of new radio diagnostic technologies like CBCT has led to significant advances in diagnosis and treatment planning and endodontics' evolution [9]. Combining CBCT and constructing a guide by Surface scan to gain a straight access cavity and avoid the risk of root perforation and fracture of instruments during preparation ([10, 11]).

Ideal irrigants should flush out debris, dissolve organic tissue, kill microbes, destroy by-products, and remove the smear layer. Achievement of these objectives, there must be an effective irrigation system [12]. Conventional irrigation by the side vented irrigating needle associated with apical positive pressure is commonly used in endodontic treatment [13]. The main disadvantage of this system is that the irrigant does not extend much beyond the irrigation needle tip, which affects the debridement efficacy of the irrigant [14].

The apical negative pressure system is an irrigation system in which the irrigant was delivered to apical areas and irregularities of the root canal [15]. It has been introduced to simultaneously release and remove the irrigant delivered to the root canal for the entire length and obtain a good fluid flow [16]. Negative apical pressure is safer than positive apical pressure because it applies suction rather than powerful injection [17].

MATERIALS AND METHODS

Sample size calculation

This study was approved by the Ethical Committee of the Faculty of Dental Medicine, Al-Azhar University, Cairo, Boys (469/2015).

Samples selection and preparation

Sixty recent extracted human mandibular first molar teeth were collected from the outpatient clinic (Department of Oral Surgery, Faculty of Dental Medicine, Al Azhar University). Teeth were extracted from patients with an age range from 18 to 40 years old with root canal curvature ranging from 15°to 30°.

Six circular plastic molds were constructed with ten rounded holes containing ten samples. A Pre-operative cone beam computed tomography (CBCT) (Ray scan, Korea) (voxel size = 0.150 mm with 90 kV,12 mA, and 15-second exposure time) was obtained for six molds with samples placed inside molds.

According to the access cavity design, samples were divided into three main groups (n=20).

Group (1): CAC.

The access was prepared to start at the central fossa and extended till dropping into the pulp chamber. Partial removal of pulp chamber roof in all directions of the canals with smoothly convergent axial walls to the occlusal surface.

Group (2): TAC.

A perpendicular projection to the occlusal surface of their canal orifices directs the bur appropriately to the root canals. An oval-shaped access to the mesial root canal orifices in a buccolingual direction and a circular access cavity to the distal canal orifice.

Group (3): GCAC.

Samples were placed in two molds and scanned with CBCT, and images were stored as digital imaging and communication (DICOM) files. The two molds were captured with a 3D intraoral scanner (Medit i500.Medit Corp. Seoul, South Korea) to create surface tessellation language files (STL). DICOM and STL files were imported into Mimics Medical Software 21 (Materialize, Leuven, Belgium).

Virtual planning of the access cavities was performed, and cavities were planned per tooth. Then, a threshold was applied to segment all teeth, and a 3D model was created. The 3D models were exported as an STL file and imported, together with the virtual planning and the STL files of surface scanning, into 3-Matic Medical software 13 (materialize, Leuven, Belgium) for the guide design. A guide was designed and 3D printed with a liquid resin material (Norton, China) using a 3D printer (Halot-lite, Shenzhen, China).

The access cavity was prepared by attaching the guide to the teeth. Access cavities were marked through holes in the guide using graphite and complete gaining of access to root canals.

Root canals were instrumented in the three main groups using the Endo Star E3 Azure rotary basic kit (Poldent, Warsaw, Poland) connected to a cordless torque-limited electric motor (Motopex, Guilin Woodpecker Medical Instrument Co., Guangxi, China) at a rotation speed of 300 revolutions per minute (rpm). According to the manufacturer's instructions, the torque setting was equivalent to 2 N cm.

Each group would be divided into two sub-groups (n=10) according to the irrigation protocol.

Group (A): side-vented irrigation needle protocol.

Irrigation was done by rinsing canals with 3ml of 5.25% NAOCL followedby3mlof17% liquid ethylene diamine tetra acetic acid (EDTA) (MD-Cleanser™ , Meta Bio-med, Chungcheong Buk-do, South Korea) followed by 3ml of 5.25 NAOCL. Finally, 3ml of distilled water as a final rinse.

Group (B): Apical negative pressure irrigation system (Endovac).

Irrigation was done by using Endovac in three cycles. In the first cycle, 3ml of 5.25% NAOCL was delivered to each root canal by MDT and activated by micro-cannula till root apex level for 20 seconds. The second cycle was performed with the same steps using 3ml of 17 % EDTA, and finally, the third cycle with 3ml of 5.25% NAOCL—a final rinse of the pulp chamber and root canals with 3ml of distilled water.

Sectioning of the teeth and evaluation

After preparation, all specimens were removed from molds. The crowns of the samples were closed with sterile Teflon tape. Longitudinal grooving on the mesial and distal walls of the crown with a diamond disc mounted on a low-speed handpiece (NSK, Nakanishi, Japan) powered by an electric motor (strong, China) followed by transverse groove all around below the cementoenamel junction then the crown splitted using mallet and chisel. The placement of Teflon tape on the mesial root and then two longitudinal grooves on the buccal and lingual walls of the roots were made without entering the lumen of the root canal and following the root slope. The roots were then longitudinally divided into two halves using a mallet and chisel.

Half of each specimen was randomly selected for imaging with a scanning electron microscope (SEM) (Quanta FEG 250) (FEI Company, Hillsboro, Oregon-USA) at 500 x to evaluate the amount of remaining debris covering the pulp chamber and mesio buccal root canals.

The following scoring system was used to detect the amount of debris:

Score 1: No debris.

Score 2: Clumps of debris covering <25% of the wall.

Score 3: Clumps of debris covering 25–50% of the wall.

Score 4: Clumps of debris covering more than 50–75% of the wall.

Score 5: More than 75% of the wall is covered by debris.

Statistical analysis

Mathematical data were recorded as mean and standard deviation (SD) values. Statistical analysis for derbies scores distribution results was performed by Kruskal-Wallis and Mann-Whitney test. Statistical analysis was done by SPSS statistical package (version 25, IBM Co. USA).

RESULTS

Results in the form of means of debris percentage in different groups and different regions were represented in Table (1) and Figure (1).

TABLE (1) Mean and standard deviation values for comparison of the mean of debris scores in different four-thirds under two irrigation protocols for the three main groups

	Pulp	Coronal	Middle	Apical
Cons A	1.25 ± 0.46^{A}	1.5 ± 0.85^{A}	1.7 ± 0.67^{B}	3 ± 2.11^{B}
Truss A	1.22 ± 0.67^{A}	1.11 ± 0.33^{A}	2.9 ± 1.79^{A}	4.38 ± 0.92^{A}
Guided A	1.11 ± 0.33^{A}	1.4 ± 0.52^{A}	1.67 ± 0.71^{B}	2.89 ± 1.63^{B}
P-value*	**0.392^{NS}**	**0.724^{NS}**	**0.036^{S}**	**0.041^{S}**
Cons B	1.1 ± 0.32^{A}	1.44 ± 0.73^{A}	1.59 ± 0.78^{AB}	2 ± 1.29^{B}
Truss B	1.6 ± 0.84^{A}	1.12 ± 0.30^{A}	2.5 ± 1.27^{A}	3.2 ± 1.93^{A}
Guided B	1.3 ± 0.48^{A}	1.38 ± 0.50^{A}	1.4 ± 0.54^{B}	1.63 ± 0.74^{B}
P-value*	**0.771^{S}**	**0.570^{NS}**	**0.050^{S}**	**0.023^{S}**

Means with different capital letters indicate significant difference; S= significant at (P-value ≤ 0.05); NS= nonsignificant at (P-value < 0.05)

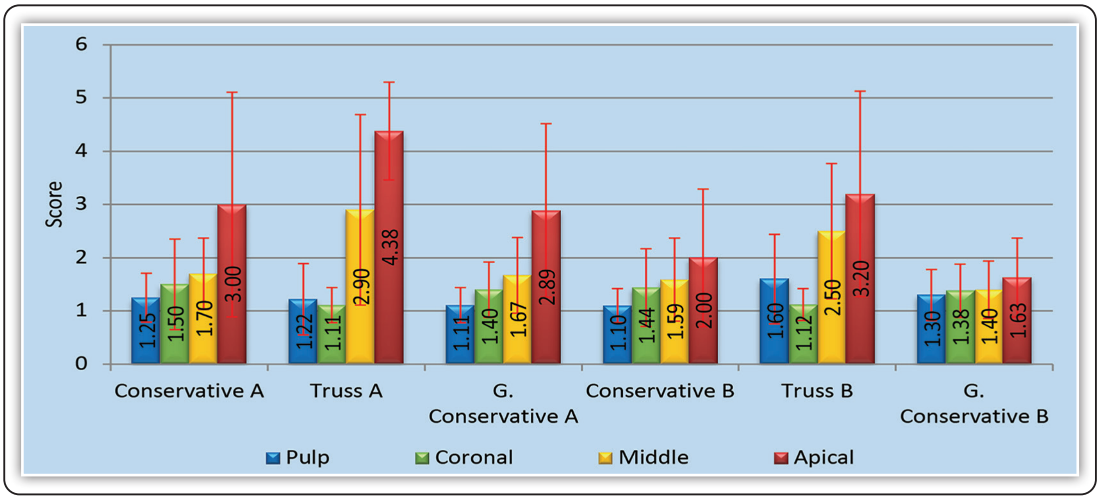

FIG (1) Bar chart represents debris scores of three main groups at different four-thirds.

For all sections, the highest mean of debris was recorded in truss access cavity design, while the lowest mean was recorded in guided conservative access cavity design. There was no significant difference in the pulp chamber and coronal regions, while the difference was significant at the middle and the apical regions.

DISCUSSION

Successful root canal treatment greatly depends on the cleanliness of the root canal system [18]. Among the variables that may affect cleanliness are the irrigating solutions and techniques used concerning the access cavity designs[19]. This experimental, randomized, controlled, interventional prospective in-vitro study aimed to evaluate the number of remaining debris covering the pulp chamber and root canals after irrigant activation using different access cavity designs.

Mandibular first molars were used as the most common teeth undergoing endodontic treatment due to their early eruption and curved mesial roots, which are considered challenging during cleaning and shaping [20]. A Preoperative CBCT was obtained to evaluate the anatomy of roots, the angle of curvature of roots, obtain an outline form of the pulp chamber and root canals, and for the planning of access cavity designs [21, 22].

The designs of the access cavity were conservative access cavity, truss access cavity, and guided conservative access cavity. The conservative access cavity preparation allows the removal of the pulp tissue and aims to preserve the soffit and peri-cervical dentin [23]. The truss access cavity preparation aimed to reinforce the coronal tooth structure by leaving intervening dentin intact [24]. The guided conservative access cavity preparation conserves the coronal tooth structure through preoperative designing and planning of the access cavity to locate canal orifices [25].

NAOCL 5.25 % was a well-established irrigant for cleaning root canals because of both its antimicrobial activity and organic tissue dissolution capability [26]. EDTA 17 % dissolved inorganic contents of the root canals [27]. Irrigation activation was done using Endovac activation system. A negative-pressure irrigating system promotes rapid circulation and continuous renewal of the irrigating solution inside the root canals [28].

This study showed that the debris collection was unrelated to the design of the occlusal access cavity. This may be attributed to the accumulation of dentin particles resulting from the rotary instrument cuts [29, 30]. TAC design had the highest mean of debris than CAC and GCAC designs, implying that ultra-conservative access cavities have more coronal interferences during root canal preparation that prevent adequate irrigation. These interferences might cause a negative consequence in the preparation, disinfection, and cleanliness of root canals. This agrees with Krishan et al. in 2014 and Moore et al. in 2016[31, 32].

Finally, the ideal access cavity should eliminate debris, necrotic substances, and remnant pulp tissue [33]. Complete removal of the pulp chamber roof is not indicated in conservative and ultra-conservative access cavity designs. Thus, these designs keep the undermined dentin of the soffit. Therefore, direct view is not applicable [34].

CONCLUSION

Within limitations of this study, the following conclusions may be drawn

- TUS preserves more tooth structure, but the dentin bridge is an obstacle to removing debris from the root canal system.
- Removal of soffit and peri-cervical dentin enhances the cleanliness of the root canal system.

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