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CBCT evaluation of volume loss with different access cavity designs using guided endodontic template

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Abstract

The aim of this study is to compare the volume loss in mandibular first molar with different endodontic access cavity with guided endodontic template using Cone Beam Computed Tomography (CBCT) evaluation. In this study, 36 freshly extracted mandibular first molars were selected and divided into three groups: A, B and C (n=12). All teeth were subjected to CBCT evaluation using CS3D software to evaluate the volume and to locate the canal orifice, following with a guide drill template were manufactured for groups B and C. Teeth in group A was prepared using Traditional endodontic access cavity (TEC), group B with truss endodontic access cavity (TREC) and Group C with ninja access cavity (NEC). The mesial canals in each group were prepared till 25/0.06 taper and distal canal till 30/0.06 taper. All teeth were again subjected to CBCT followed by volume analysis to evaluate the loss of volume. Statistical analysis was performed using one-way analysis of variance. The results indicated hard tissue loss was more in teeth with TEC compared to TREC & NEC. TREC showed less amount of volume loss compared to NEC.

Keywords: CBCT, Traditional endodontic access, truss access cavity, ninja access, Guided endodontic template, volume loss

Introduction

Endodontic therapy comprised of three factors and they were cleaning and shaping, disinfection and three-dimensional obturation of the root canal system. However, Access cavity preparation is known to be one of the most challenging and an important step for a successful endodontic treatment. Inadequate access cavity preparation may also result in difficulty in locating or negotiating the root canals, instrument separation and aberrations of the canal shape which may result in inadequate cleaning, shaping and filling of the root canal system. This may lead to failure of the treatment. For a long time, G. V. Black's preparations were totally accepted by the profession. Traditional endodontic access cavities (TEC), it emphasizes on straight line access into the root canals and this helps to increase the biomechanical preparation efficacy and reduce the procedure errors. However, a concern related to TECs is the amount of tooth structure removed, which may reduce its resistance to fracture under functional loads.[1, 2] The most current evolutionis a minimalistic approach to access design by shifting the outline configuration toward greater dentin preservation andidealizing the endodontic-restorative interface.[3] Recently, Clarkand Khademi modified the endodontic access cavity design tominimize the tooth structure removal and this was known as the Conservative endodontic access cavity (CEC). The aim of the CEC was to preserve some of the chamber roof and thepericervical dentin.[4] This region of dentin is believed to be important in minimizing root fracture seen in endodontically treated teeth, as it is an area responsible for redistributing occlusal forces through the long axis of the root.[4]

Inspired by the minimally invasive dentistry concept, conservative endodontic access cavity (CEC) preparation was proposed to preserve tooth structure maximally. [5,6] Some endodontists have emphasized this principle by creating “ninja” and “truss” endodontic access cavities.

A ninja endodontic cavity consists of a small hole on the occlusal surface that should allow the clinicianto find and access all of the canal orifices.[7]On the other hand, a TREC consists of direct access from the occlusal surface to each canal orifice, avoiding removal of whole pulp chamber roof.[8]

Cone beam computed tomography (CBCT) has been recently recommended in endodontics as a diagnostic aid in planning and execution of root canal treatment because of its enhanced capacity to reveal the detailed morphology of the roots.

CBCT uses an extraoral imaging scanner to produce three dimensional (3 D) scans of maxillofacial skeleton at a considerably low radiation dose than conventional CT scanning and has been shown to be more accurate than digital radiography in assessing root canal morphology. [9,10]

A procedure involving straight line access to the root canal with the help of a guided endodontic template can be used to gain a straight-line access in root canal treatment.

In guided endodontics, a pathway is used to guide th endodontic bur to the exact area. CBCT data and 3D surface scan of the teeth is superimposed in a software which help to create the virtual image of a commercially available drilling bur of specific dimensions.[11]

The virtual bur, superimposed on the targeted tooth, is manually angulated to create straight line access. After this, a virtual template is designed in the software and exported to the 3 D printer in standard tessellation language (STL) format. The physical model of the drilling guide is then used for access preparation.

Till date, there are no studies that assessed the hard tissue volume lost with different access cavity designs. Thus, the aim of this study is to compare the hard tissue volume loss in mandibular first molar with different endodontic access cavity: Traditional, Truss and Ninja access cavity preparation using CBCT evaluation.

Material and methodology

Sample selection: 36 freshly extracted mandibular first molars with approximately equal hard tissue volume and length (as confirmed with radiographs and CBCT using CS3D software evaluation) with mature apices belonging to patients between 20 and 60 years were collected. The teeth had no visible carious lesion, restoration, crack or fracture. After debriding the tooth surface using hand scaling instruments and cleaning the root and crown surfaces with a rubber cup and pumice paste, the teeth were stored in 0.9% saline at 4°C until the experiment and during different phases of intervention to prevent dehydration were selected for the study.

Access preparation

The samples were randomly divided into three groups depending on the access preparation as follows:

Group 1: traditional endodontic access cavity

Group 2: Truss access cavity

Group 3: ninja endodontic access

Teeth with almost similar shape and size were allocated to each group for the purpose of standardization and in order to minimize the effect of variable sizes and shapes of the teeth on the results.

In group 1 traditional access cavity was performed in a standard way by deroofing the entire pup chamber roof. (Figure 4)

Template preparation

For groups 2 and 3 a drill was virtually designed by applying the SimPlant software implant designer tool and virtually overlapped over the root canal. The axis of the drill was angled in such a way that the tip of the extended drill would reach the radiographically visible lumen of the root canal. After planning the position of the drill, a virtual template was designed, applying the SimPlant software template designer tool. A guiding sleeve (3.0-mm external diameter, 1.5-mm internal diameter, and 8-mm length) was customized for the drill by means of a software tool. Fixation sleeves were also created for the purpose of stabilizing the guide, preventing the perforation drill from deviating from its trajectory created based on the tomographic planning. The virtual template was exported as an STL file and sent to a 3D printer. (Figure 1 and 2) The previously mentioned sleeve was integrated into the printed template to guide the drill during cavity preparation. With this drill (figure 3), a small marking was made on the occlusal surface and them the long thin tapered fissure bur was used to continue through the marking to reach the orifice, the opening was enlarged using a straight fissure bur in all the samples (figure 5), in group 3 the dentin bridge was broken to create ninja/x-entry access preparation (figure 6).

Canal preparation

A single operator instrumented all the root canals using the NiTi ProTaper Rotary system (Dentsply Maillefer). The cervical and middle thirds of the canals were flared using the ProTaper SX and S1 rotary instruments. The mesial canals were then finished using instruments F1 and distal canals were finished first with F1 and then with F2 until the working length was reached. At each instrument change, canals were irrigated with a 2.5% sodium hypochlorite (NaOCl) solution using a total of 25 mL per specimen. After completion of root canal instrumentation, 5 mL 17% EDTA was applied for 3 minutes to remove the smear layer, and canals were irrigated again with 5 mL 2.5% NaOCl solution.

CBCT evaluation using CS3D software and volume analysis using ITK snap software was performed for all the selected samples before and after the access preparation and compared for calculating the amount of hard tissue volume lost. (Figure 7,8)

Statistical analysis:

Data were analysed using R software. Two-way ANOVA was applied to evaluate the hard tissue volume lost in different groups. Further, multiple comparison of groups was done using Tukey test in this respect at $p<0.05$ level of significance.

Results

The pre-operative volume and volume after access preparation and instrumentation for all the samples were recorded. Volume lost in these samples were calculated by subtraction of these values. The mean value for hard tissue volume lost was calculated and statistical analysis was performed (Table 1). The Tukey test revealed significant difference in loss of hard tissue volume between groups with traditional and Truss access cavity and also between groups with traditional and ninja access (P value less than 0.05). There was no significant difference between truss access group and ninja access group (P value more than 0.05).

Table1: Mean Value and percentage of volume loss in all the groups

Groups	Mean volume of volume loss (mm^3)	Percentage of volume loss (%)
TEC (A)	71.2	9.1
TREC (B)	13.9	1.8
NEC (C)	24.8	3.3

Results

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Discussion

Mandibular molar was chosen for assessment due to its common indication for endodontic treatment and high incidence of fracture among all teeth and also, they hold the first spot on the list of teeth requiring endodontic intervention, and having the least survival rates, thus prioritizing them when researching different access cavity designs that may prolong life expectancy of the teeth. [13,14]

Multiple studies comparing a conservative access to a traditional access have found that traditional access cavities may render a tooth more susceptible to fracture than those with a conservative access.[7,15]

In endodontic treatment of posterior teeth, the main problem with cavities prepared using the TEC method is that there is loss of more tooth structure. Among mandibular molar teeth, occlusal enamel and dentin located at the center of a tooth are subject to high chewing pressure.[16]By preserving the pulpal chamber roof using contracted cavity preparation, the aim is to distribute the occlusal forces before they reach the pulpal chamber floor. Jiang et al. reported that protecting the tooth tissue in endodontic treatment can enhance the tooth fracture strength.[15]

Overestimating the CEC concept, there came the so-called ultraconservative endodontic access cavities (UEC), also popularly known as “ninja” access (Plotino et al. 2017),[7] and truss-access or orifice-directed design cavities (Neelakantan et al. 2018).[8]

Removal of hard tissue increases cuspal flexure under occlusal load and this in turn influences the strength of fracture. Therefore, a proper and conservative endodontic access cavity designs could improve the prognosis for an endodontically treated tooth.

In the present study, the largest loss of hard tooth structure was caused by traditional access cavity. The loss of tooth structure caused by access cavity designs in this study bears perhaps, the most relevant clinical implication.

The maintenance of the “truss” provides added strength. Truss access is the design of choice in a mandibular molar when the canal convergence is minimal, and the platform is wide. The preserved dentin structure helps to resist tensile and compressive forces by bracing the lingual and buccal dentin walls.[17]

The results from this study showed more amount of hard tissue volume loss in traditional access cavity groups suggesting reduced fracture strength and increased susceptibility to fracture.

Truss group showed least amount of hard tissue volume loss suggesting improved stability in these teeth and the difference between TREC and NEC was not statistically significant.

Although CEC, NEC, TREC improved fracture strength more than TEC, it could increase the risks of inefficient canal instrumentation and the occurrence of procedural errors as previously reported.

The primary aim of endodontic treatment is to eliminate microorganisms.[11] Research has established that bacteria can penetrate into and colonize almost half the length of dentinal tubules.[18] Accordingly, inadequate removal of infected dentin within the canals can decrease the prognosis and lead to posttreatment failures. However, a recent study showed that CECs in maxillary molars did not appear to impact instrumentation efficacy.[19]

While the mechanism of vertical root fracture is debated and not well defined, knowledge of contributing factors is an important treatment consideration. The results of this study support the use of CEC to facilitate the conservation of pericervical dentin and prevent unnecessary reduction in fracture resistance.

Conclusion

Within the limitations of this study, it can be concluded that there was a significant difference of hard tissue volume loss between traditional access cavity group compared with truss and ninja access cavity. The truss endodontic access cavity showed minimal loss of hard tissue volume than Ninja endodontic access cavity even though the difference between them was not statistically significant.

Figure 1: 3-D template

Figure 2: Template with sleeve

Figure 3: Guide drill

Figure 4: traditional endodontic access cavity

Figure 5: TREC with the guided template

Figure 6: NEC with guided template

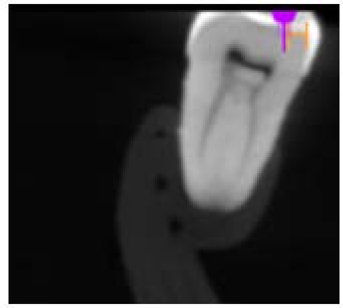

Figure 7: CBCT image of mandibular molar before instrumentation

a b c

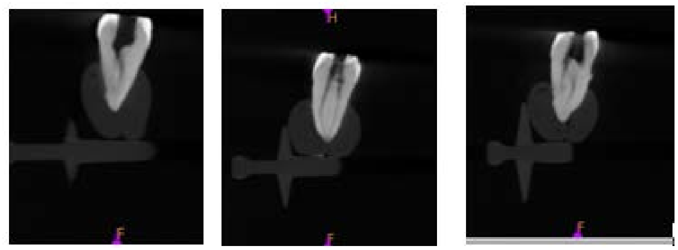

Figure 8: CBCT images of mandibular molar after instrumentation

(a: traditional access, b: truss access, c: ninja access)

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