Cone beam computed tomographic evaluation of two access cavity designs and instrumentation on the thickness of peri-cervical dentin in mandibular anterior teeth

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Abstract

Background and Objectives: The aim of the study was to determine the effect of two access cavity designs on the peri-cervical dentin thickness before and after instrumentation using cone beam computed tomography (CBCT).

Materials and Methods: Sixty mandibular anterior teeth were divided into two groups of thirty teeth each: Group I: Conventional access cavity preparation, where access was prepared just above the cingulum and Group II: Incisal access cavity preparation, where access was prepared in proximity to the incisal edge. CBCT scans were taken preoperatively, following access cavity preparation and post instrumentation. 200 μm thick slices were obtained 4mm apical and coronal to the cemento-enamel junction. The peri-cervical dentin thickness was calculated on the facial, lingual, mesial, and distal for all the three obtained scans.

Results: The analysis showed that access cavity preparation and instrumentation resulted in a significant loss of tooth structure in Group I on all surfaces, but in Group II, there was a significant loss of tooth structure only in the mesial, lingual, and distal surfaces (P < 0.05).

Conclusion: Incisal access cavity preparation resulted in lesser loss of dentin in the peri-cervical region.

Keywords: Cone beam computed tomography; incisal access cavity preparation; peri-cervical dentin; Protaper

INTRODUCTION

For a successful root canal treatment, factors such as a thorough knowledge of root canal morphology, access cavity design, and chemomechanical preparation techniques have to be taken into consideration. An ideal access cavity should help in locating canal orifices, permit direct access to the initial canal curvature, and also conserve tooth structure.

The mandibular incisors are the smallest of human adult teeth, being broad and flat labiolingually, and in about 41.4% of the cases, they are reported to have two canals. The conventional endodontic access cavity for the mandibular central and lateral incisor is located just above the cingulum and is extended labiolingually with a final ovoid outline. This design has many drawbacks and does not adhere to the main objectives of the access preparation. It can result in increased removal of tooth structure from the central portion of the tooth which compromises the resistance of the tooth to fracture. It is generally accepted that the amount of remaining dentine is directly related to the strength of the tooth and it has been observed that...
there is a direct correlation between the root thickness and the ability of the tooth to resist lateral forces and avoid fracture. Researches are hence looking at modifications of the traditional access cavity design of the mandibular incisors.

One such modification in access design is the “incisal approach.” It provides straight line and unimpeded access to the apical third of the root, reducing the risk of perforations and better preparation, especially in the apical third of the canal. It is beneficial for patients with limited mouth opening and preserves the mechanism of anterior guidance which protects the posterior teeth during protrusion by being positioned in the nonfunctional surface of the tooth.

The conventional access cavity preparation for mandibular anterior teeth is believed to greatly compromise tooth structure in the peri-cervical dentin region. This is an area of tooth surface which extends roughly 4 mm above and 4 mm apical to the crestal bone. Modified incisal access cavity design that conserves the peri-cervical dentin is thus to be considered to improve the fracture resistance.

Cone beam computed tomography (CBCT) uses an extraoral imaging scanner to produce three-dimensional (3D) scans of the maxillofacial skeleton at a considerably lower radiation dose than conventional CT scanning and has been shown to be more accurate than digital radiographs in assessing root canal morphology.

Literature review gives limited information regarding the incisal approach and its influence on the peri-cervical dentin in mandibular anterior teeth using CBCT. Hence, the purpose of this study was to evaluate the effect of two access cavity designs and instrumentation on the thickness of peri-cervical dentin in mandibular anterior teeth using CBCT visualization technique.

**MATERIALS AND METHODS**

Sixty freshly extracted human mandibular anterior teeth were collected, stored, and handled according to the Occupational Safety and Health Administration and the Centre for Disease Control and Prevention recommendations and guidelines. Digital radiographic images of the teeth were obtained. Teeth with dental caries, immature apices, cervical abrasions, previous restorations or endodontic manipulation, accessory canals, calcifications, fractures or crack, internal or external resorption, and dilacerations were excluded from the study.

A plastic template was made to standardize the position and angulations of the specimens for the CBCT scans (Kodak 9000 3D, Carestream Dental, USA). Scans were taken at three stages during the study for both the groups, i.e., preoperative, following access cavity preparation, and postinstrumentation. Eight 200 µm sections were chosen for evaluation in the scan, extending 4 mm below the cemento-enamel junction (CEJ) to 4 mm above the CEJ.

Sixty specimens were randomly divided into two groups of thirty each:

- **Group I:** Conventional access cavity preparation - The initial point of entry with the bur (endodontic access cavity preparation burs #1, Dentsply Maillefer, Ballaigues, Switzerland) was just above the cingulum with the bur angled perpendicular to the surface of the entry point. After locating the canal, the bur was used to roughly extend the access into an oval outline. The orifice opening was performed using Protaper SX (Dentsply Maillefer, Ballaigues, Switzerland) to provide continuous smooth walls down the chamber into the canal.

- **Group II:** Incisal access cavity preparation - The initial point of entry with the bur was kept short of the incisal edge in the lingual surface of the crown, with the bur (endodontic access cavity preparation burs #1, Dentsply Maillefer, Ballaigues, Switzerland) being held parallel to the long axis of the tooth. The opening was enlarged until the cavity extended cervically to the center of the lingual surface, incisally to involve half of the bucco-lingual width of the incisal edge, and mesiodistally to include the entire pulp chamber. The orifice opening was performed using Protaper SX (Dentsply Maillefer, Ballaigues, Switzerland) to provide continuous smooth walls down the chamber into the canal.

After the access cavity preparation, the teeth were repositioned in the template, and a second scan was taken. The root canals were scouted with #10 K file (Mani Inc., Japan) and checked for patency. Working length was determined radiographically, and Glyde path was established up to the working length with a #20 K file. Instrumentation for both the groups was done with Protaper Rotary system (Dentsply Maillefer, Ballaigues, Switzerland) with S1 and S2, followed by the use of finishing files F1 and F2 up to the working length. Canals were irrigated with 3% NaOCl and saline, in between each instrument, delivered by a 26-gauge needle, allowing for adequate back flow. Following instrumentation, the teeth were repositioned in the template, and a third CBCT scan was taken.

As the peri-cervical dentin extends 4 mm above and 4 mm below the CEJ, sections of 1 mm from this region were obtained and the peri-cervical dentin thickness was analyzed for both the groups. The peri-cervical dentin thickness was calculated as the shortest distance from the canal outline to the closest adjacent root surface, which was measured in four surfaces, that is, facial, lingual, mesial, and distal for all the groups in the three obtained scans [Figures 1 and 2].
**Statistical analysis**
The data so obtained were compiled systematically. A master table was prepared in Microsoft Excel worksheet, and SPSS version 10.5 (SPSS Inc., Chicago, USA) software package was used for data entry and analysis. The data were subdivided and distributed meaningfully and presented as individual tables along with graphs. The results were averaged (mean ± standard deviation) for each parameter for continuous data. The ANOVA test was used to determine whether there was a statistical difference between the groups in the parameters measured. $P < 0.05$ was considered statistically significant.

**RESULTS**
The parameters were analyzed using ANOVA followed by Tukey’s pairwise comparison.

The loss of peri-cervical dentin following access cavity preparation and instrumentation was more significant in Group I than in Group II ($P < 0.05$) [Graphs 1 and 2].

**DISCUSSION**
Disadvantages associated with the traditional lingual access opening in lower anterior teeth are lack of straight line approach to the apex, undetected canals, and inadequate chemomechanical preparation. The incisal access cavity provides a straight line approach to the apex, giving complete apical control of instruments and preventing iatrogenic errors such as gouging of the labial wall, ledging, and perforations, which commonly occur as a result of failure to recognize the 20° lingual axial inclination of the tooth. It is also indicated in anterior teeth with an existing resin-bonded prosthesis. Incisal access is also highly encouraged in patients with limited mouth opening (post-trauma maxillo-mandibular fixation) and in cases of crowded teeth. In Angle Class II, division 2 dentitions, it is the most practical approach.

Peri-cervical dentin thickness measurement is one way of analyzing the loss of tooth structure, following access preparation and instrumentation. In anterior teeth, this area is considered critical for three reasons: Ferrule, fracture, and the dentinal tubular orifice that opens from the inside to outside. For a long-term prosthetic restoration to stay in the oral cavity, a 3D ferrule should be present, which includes a vertical component, dentin girth (thickness), and taper. The CBCT scan recorded four sections above and four sections below the CEJ which was considered to be the peri-cervical dentin. The amount of remaining dentin at this junction which is the most critical area in clinical situation was measured along the facial, lingual, mesial, and distal surfaces.

**Peri-cervical dentin measurement following access cavity preparation**
In Group I, it was observed that there was a significant loss of peri-cervical dentin in the facial, lingual, mesial, and distal surfaces following access preparation. In Group II (incisal access cavity), a significant loss of...
peri-cervical dentin was observed only in the lingual and distal surfaces as compared to other two surfaces. Peri-cervical dentin loss was more significant in Group I than in Group II.

These findings were in accordance with a study done by Logani et al. where they compared the conventional lingual access to labial access preparation in mandibular anterior teeth in terms of achieving maximum conservation of coronal tooth structure by weighing the tooth before and after the access cavity preparation; it was seen that the tooth tissue lost during lingual access was significantly more than that lost during labial access preparation. It was concluded in this study that a labial access opening for endodontic treatment of mandibular incisors would facilitate straight line access to canals more consistently and conservatively.[21]

**Peri-cervical dentin measurement following instrumentation**

Instrumentation resulted in a significant loss of peri-cervical dentine in both the groups. In Group I, it was observed that there was a significant loss of peri-cervical dentin on all the surfaces. In Group II, there was a loss of tooth structure observed in the facial, lingual, and distal surfaces. When the amount of peri-cervical dentin lost in both the groups was compared, it was observed that the loss was more significant in Group I. It was observed that at both the stages of measurement (i.e., following access preparation and instrumentation), incisal approach in mandibular incisors conserved tooth structure, especially in the cervical region.

Although there exists immense literature about the significance of maintaining dentin in the longevity of endodontically treated teeth, there is limited literature on the effect of location of access and subsequent instrumentation on the peri-cervical dentin. This study was hence an attempt to analyze the effect of two different access cavity preparations on the peri-cervical dentin using a noninvasive method, the CBCT.

Studies by Magne and Belser also stress the importance of maintaining the cingulum and lingual fossa. The lingual concavity is shown to be an area of stress concentration, whereas low stress levels were found in the surfaces of maximum convexity, i.e., the cingulum and the cervical part of the facial surface. Thick enamel of the cingulum and the marginal ridges can thus act as stress redistributors. The incisal approach helps preserve this important landmark and contributes to the longevity of the tooth.[17]

In preparing endodontic access, the danger of using round bur is highlighted rightly by Clark and Khademi (CK). There is a chance of creating an inverse funnel shaped gouged access compromising the dentin in the peri-cervical region. To overcome this, the use of CK endodontic access bur with its tapered round ended design allows the formation of a true funnel where the narrow portion of the funnel is in the peri-cervical dentin zone. The authors also propose positioning the access closer to the incisal edges.[18] Access prepared in the lingual approach (Group I) probably could have resulted in gouging and inadvertent removal of the dentin in the region.

Further studies on the influence of different access preparation approaches on the quality of obturation, postendodontic restorations and fracture resistance could be done before incorporating this technique into our routine clinical practice.

**CONCLUSION**

Within the limitations of this in vitro study, the following conclusions can be drawn:

Both the experimental access cavity designs resulted in the loss of tooth structure in the peri-cervical region following access as well instrumentation of the root canal. Conventional access cavity preparation resulted in a significant loss of tooth structure in the peri-cervical region as compared to incisal access cavity. Hence, it may be concluded that incisal cavity design is a more conservative approach to access mandibular incisors.

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**Conflicts of interest**
There are no conflicts of interest.

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