Original Article

Cone-beam computed tomographic analysis of canal convolution in mesial root of mandibular second molars and a proposed new classification

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Abstract

Aim: The aim is to evaluate the anatomical characteristics of mesiolingual and mesiobuccal canals in mandibular second molars particularly in terms of its exit direction, distance of confluence from the minor constriction, and the angle of confluence.

Materials and Methods: The cone-beam computed tomography images of hundred mandibular second molars were analyzed. Endodontically treated teeth and those with anatomical variations such as C-shaped canal configuration were excluded from this study. The distance of the confluence from the minor constriction, angle of confluence, and the exit direction of the mesiobuccal and the mesiolingual canals were assessed. Data were analyzed using an independent *t*-test.

Results: The course of the mesiobuccal and mesiolingual canals beyond the confluence was towards the center of the root. The average angle of confluence was 32.75°–35.28°. The average distance of confluence from the minor constriction was 2.19 to 2.68 mm. The mesiolingual canal was straighter whereas the mesiobuccal canal had a tortuous course. Considering the results of the present study, a new classification has been proposed for the root canal morphology of the mesial root of mandibular second molars.

Conclusion: The variation in the morphology of mandibular second molars highlights that the mesiolingual canal presented a mild curvature through and beyond the confluence when compared to the mesiobuccal canal which exhibited a tortuous course through the confluence.

Keywords: Anatomy; cone-beam computed tomography; confluence; molars

INTRODUCTION

The success of an endodontic treatment is mainly dependent on the cleaning and shaping of the root canals, its proper disinfection, and a hermetic seal of the root canal system. Along with these protocols, the knowledge of the internal anatomy of the tooth is of utmost importance.[1] Preoperative recognition of canal complexities such as number of canals, curvatures, and confluences can aid in reducing procedural errors.[2]

Similar to the mandibular first molar, the root canal morphology of the mandibular second molar typically exhibits two mesial canals and one distal canal. The root canals in the mesial root may have a common foramen or exit separately as two or more foramina, but merging of the two canals is most commonly encountered.[3]

The early identification of confluences, where canals converge and meet, holds clinical significance as they often

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result in abrupt multiple curvatures. These curvatures can potentially overstress nickel–titanium instruments and cause iatrogenic errors such as instrument failure.[4-6]

To overcome this problem, Vertucci proposed preparing the less complex canals till the working length and the more complex canals only up to the point where the canals meet.[2] This provides the clinician with have better understanding of the confluence thereby aiding in treating the canals more precisely and minimizing the occurrence of iatrogenic errors.

Radiology serves as an indispensable tool in endodontic practice wherein the most routinely utilized are the traditional intraoral periapical radiographs. However, traditional radiography has its limitations as it is a two-dimensional representation of a three-dimensional object and also causes anatomical noise. Angulated radiographs are also less contributory as it provides only a limited perspective of the three-dimensional configuration of root canals.

Advances in imaging technology such as cone-beam computed tomography (CBCT) have gained popularity because it allows a three-dimensional analysis of internal dental morphology and provides precise measurements of dental structures such as the configuration of the root canal system.[7,8]

There is limited literature regarding the morphology of the mesial root of mandibular molars pertaining to the course of mesiobuccal and mesiolingual canals, its confluence, and the angle of confluence.

Therefore, this study aimed to evaluate the distance of confluence from the minor constriction, angle of confluence, and the direction of exit of mesiobuccal and mesiolingual canals in mandibular second molars.

The null hypothesis stated that there will not be any difference in the anatomy of the mesial root of mandibular second molars in terms of the course of the mesiobuccal and the mesiolingual canal pertaining to its direction of exit point, angle of confluence, distance of confluence from the minor constriction and the straightness of the canal.

MATERIALS AND METHODS

The present study was approved by the Research Committee of Manubhai Patel Dental College and Hospital under the approval no. MPDC_234/CONS-43/21. Hundreds of CBCT images of two-rooted mandibular second molars were collected as secondary data from Dentscan Imaging Center, Vadodara, with a confidence interval of 95% and power 80%. CBCT images had been taken using the Veraview Pox 3D (J Morita, Kyoto, Japan) operating at 90 kVp and 5 mA, with a field of view of 4 cm × 4 cm and voxel size of 0.125 mm. The evaluation of the CBCT scans was done by a single experienced endodontist. The course of mesiolingual and mesiobuccal canals was evaluated in terms of their direction and exit point, the distance of the confluence from the minor constriction [Figure 1a-c] and angle of confluence [Figure 1d-f]. The canal with single or mild curvature was considered as a straighter canal whereas the canal with more than one curvature was considered to have a complex route. Single-rooted teeth, previously root canal-treated teeth, C-shaped canal configuration, or any aberrations noted in the root canal morphology were excludeed from the study. CBCT images were aligned along the long axis in the coronal section and evaluation regarding the measurements in terms of the distance of the confluence from the minor constriction as well as the angle of confluence was made using the measurement tools of One Volume Viewer Software.

Statistical analysis

The results were analyzed statistically with the significance set at $P < 0.05$. An Independent *t*-test was used to compare the difference between the buccal and lingual straighter canals on the basis of the distance of confluence from minor constriction and angle of confluence.

RESULTS

In the present study, 55% of the cases had confluent canals, 35% had no confluence and the remaining had confluence at the apex. Considering the course beyond the confluence, 32% were towards the lingual side of the root, 18% were on the buccal side and 49% being toward the center of the root, respectively [Table 1].

Table 2 depicts that, the average distance between confluence and minor constriction was 2.19 mm when the mesiobuccal canal was straighter and 2.68 mm when the mesiolingual canal was less tortuous with standard deviations of 0.542 and 0.747, respectively. However, the

Table 1: Frequency distribution showing different types of canals under study

Types of canals	Frequency, *n* (%)
Confluent canals	55 (55)
Nonconfluent canals	35 (35)
Confluence at the apex	10 (10)
Straighter canal	
Mesiobuccal	19 (34.50)
Mesiolingual	36 (65.50)
Course beyond the confluence	
Lingual	18 (32.70)
Buccal	10 (18.20)
Centre of the root	27 (49.10)

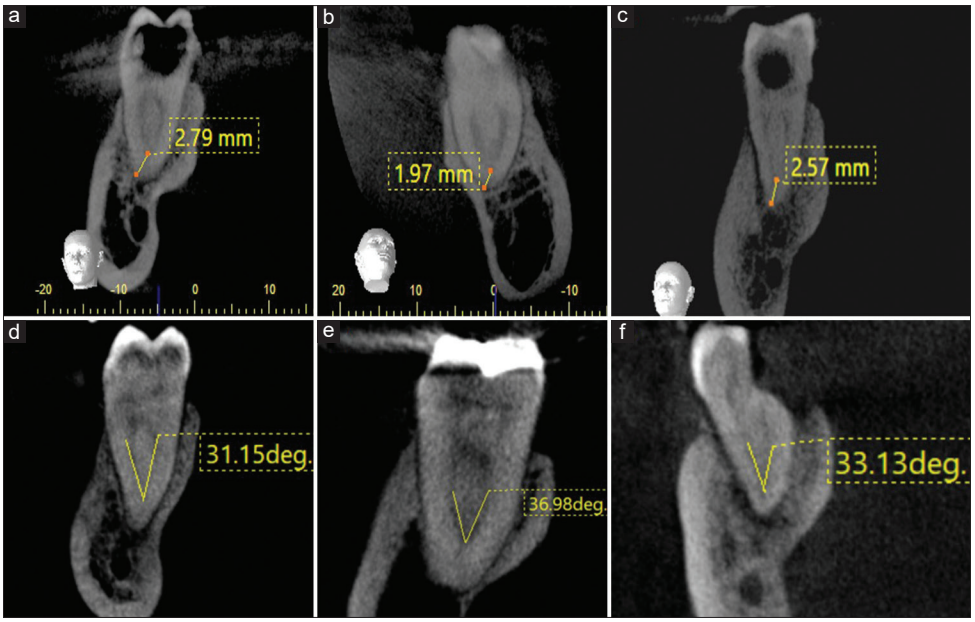

Figure 1: (a-c) The distance of confluence from the minor constriction. (d-f) The angle of confluence

Table 2: Descriptive statistics of distance and angle of confluence for buccal and lingual canals

Straightness of the canal	*n*	Mean	SD	SE mean
Distance				
Mesiobuccal	19	2.195	0.542	0.124
Mesiolingual	36	2.682	0.747	0.124
Angle				
Mesiobuccal	19	35.284	9.402	2.157
Mesiolingual	36	32.756	7.446	1.241

SD: Standard deviation, SE: Standard error

Table 3: Depicts the difference between buccal and lingual canals on the basis of distance and angle of confluence

Straightness of the canal	*t*	df	Significant (two-tailed)	Mean difference	95% CI	
					Lower	Upper
Distance	−2.511	53	0.015	−0.487	−0.876	−0.098
Angle	1.092	53	0.028	2.527	1.005	7.170

CI: Confidence interval

mean angle of confluence was 35.28° when the mesiobuccal canal was straighter and 32.75° when the mesiolingual canal had a less complex route.

Table 3 suggests that, there was a statistically significant difference in the distance, where the distance of confluence from the minor constriction was significantly higher when the mesiolingual canal was comparatively straighter than the mesiobuccal canal. In addition, angle of confluence also showed significant difference between mesiobuccal and mesiolingual canals where the mean angle of confluence was higher when the mesiobuccal canal was straighter as compared to the mesiolingual canal. Based on the results of the study, a CBCT based classification has been proposed describing the root canal morphology of mesial root of mandibular molars (Copyright Number: L-108414/2021) [Figure 2].

DISCUSSION

The present study focused more on the canal complexity in the mandibular second molars particularly in the mesial root because variations are more commonly noted in these teeth.[9] However, this variation is population specific.[10] Several authors believe that the most important parameters to consider when evaluating a case are the number and length of root canals along with the presence of canal confluence.[2,11]

Canal confluence in the mesial roots of mandibular molars reportedly range from 21% to 76%.[12-15] However, it is rarely detected on conventional radiographs because of canal superimposition, thereby making it more challenging to be predicted preoperatively. In this study, incidence of confluence in the mesial roots of mandibular second molars was found to be 55%.

The average distance of the confluence from the minor constriction was 2.19–2.68 mm. On the other hand, Cimilli *et al*. reported an average distance of only 0.19 mm in 34 mesial roots with canal confluences.[16]

A clear understanding regarding the location of confluence is important so as to avoid over-instrumentation in the apical third of the root. Hence, the straighter canal can be prepared till the working length whereas the canal with a tortuous route can be instrumented till the level of confluence.

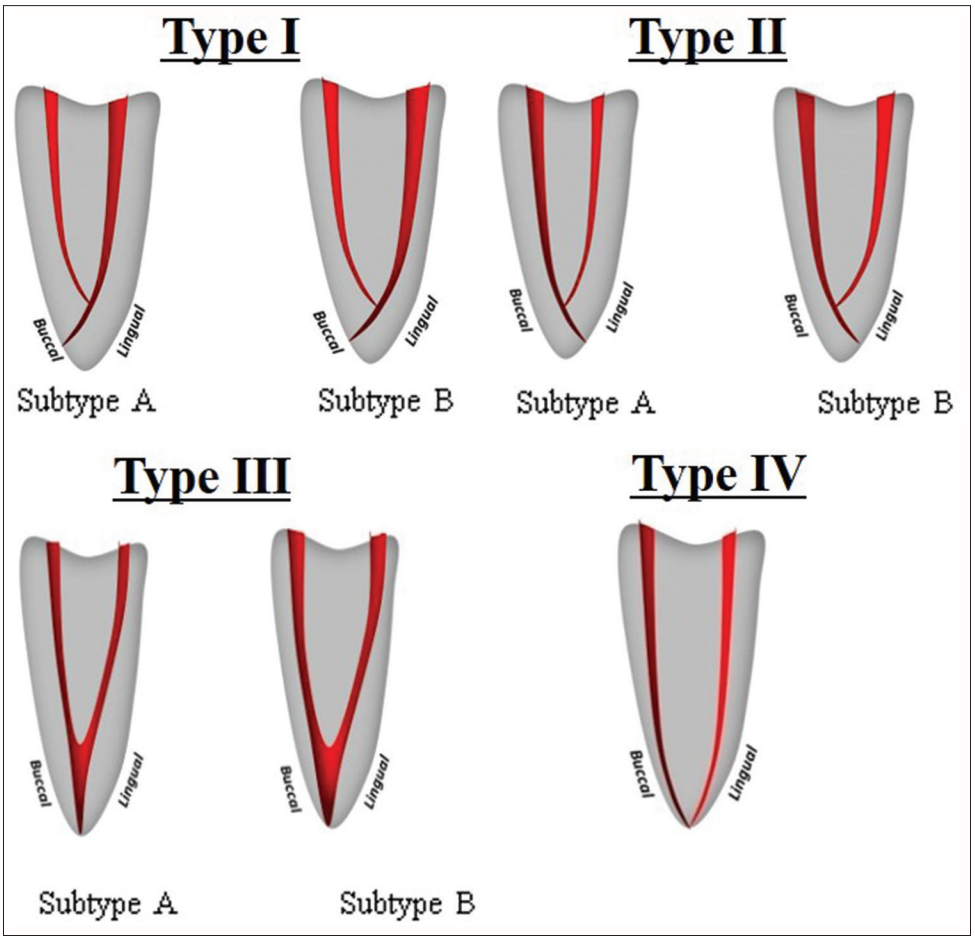

Figure 2: Line diagram depicting the cone-beam computed tomography (CBCT)-based classification for mesial root of mandibular second molars. The proposed CBCT based classification for root canal configuration of mesial root of mandibular second molars. Type I: Buccal exit in continuity with lingual canal beyond the confluence. Subtype A: The mesiobuccal canal joins the mesiolingual canal forming a mild angle * at the level of confluence with the exit on the buccal side of the root. Subtype B: The mesiobuccal canal joins the mesiolingual canal forming a severe angle # at the level of confluence with the exit on the buccal side of the root. Clinical implication – The mesiolingual canal can be treated first till the working length whereas the mesiobuccal canal can be prepared till the level of confluence. Type II: Lingual exit in continuity with buccal canal beyond confluence. Subtype A: The mesiolingual canal joins the mesiobuccal canal forming a mild angle * at the level of confluence with the exit on the lingual side of the root. Subtype B: The mesiolingual canal joins the mesiobuccal canal forming a severe angle # at the level of confluence with the exit on the lingual side of the root. Clinical implication – The mesiobuccal canal can be treated first till the working length whereas the mesiolingual canal can be prepared till the level of confluence. Type III: Exit from the center along long axis of the root beyond confluence. Subtype A: The mesiobuccal canal joins the mesiolingual canal forming a mild angle * at the level of confluence and exits through the center of the root. Subtype B: The mesiobuccal canal joins the mesiolingual canal forming a severe angle # at the level of confluence and exits through the center of the root. Clinical implication – The mesiolingual and the mesiobuccal canal can be prepared individually till the working length. Type IV: Confluence at the constriction at the center along the long axis of root. *mild angle: Where the angle of confluence was between 25° and 35°. #severe angle: Where the angle of confluence was between 35° and 51°

High incidence of confluence is noteworthy in retreatment cases with previously fractured instrument. In general, the separation of the instrument is at the level of confluence with patency maintained in the apical third of the root. Therefore, file bypass can be done in the canal where apical patency is maintained and the other canal can be prepared till the level of fractured instrument.[17]

In the present study, the mean angle of confluence was higher when the buccal canal was straighter as compared to the lingual canal. Having a knowledge of the same helps us to prevent iatrogenic errors such as file separation in the critical area of the root. Moreover, the difficulty of treating the tooth will be less when the lingual canal is straighter as the angle of confluence is less.

All the measurements regarding the distance of the confluence from the apical foramen and the angle of the confluence were made using the in-built software. Hence, the error related to the perception of CBCT findings can

be considered as one of the limitations of the study. To overcome this, further studies can be carried out using a digital software for accurate and consistent measurements.

CONCLUSION

It can be concluded that in mandibular second molars, mesiolingual canal continued through and beyond the confluence having a less tortuous course when compared to the mesiobuccal canal.

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Conflicts of interest
There are no conflicts of interest.

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