Morphological measurements of anatomical landmarks in human maxillary first molar pulp chambers and evaluation of number of pulp canal orifices using spiral computed tomography: An in vitro study

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Abstract

Context: Comprehensive understanding of the anatomic position of pulp canal orifices and the measurements of the molar pulp space may maintain the pulp health during conservative tooth preparation and minimize the possibility of mishaps during endodontic therapy.

Aims: The idea of the present study was to analyze the morphological measurements of anatomical landmarks in human maxillary first molar pulp chambers and evaluation of number of pulp canal orifices using three-dimensional spiral computed tomography (SCT).

Subjects and Methods: One hundred and thirty extracted intact human adult maxillary first molars were chosen from the North Indian population and were analyzed using SCT in axial and coronal sections.

Statistical Analysis Used: Standard deviation, mean, and coefficient of variance were calculated. Interobserver reliability was evaluated using kappa value to avoid any bias.

Results: The results from our study showed that 69.23% of the sample teeth had four canal orifices, the mesial and distal pulp horns were present at an average distance of $0.80 \pm 0.36$ mm and $0.41 \pm 0.34$ mm, respectively, above the cementoenamel junction (CEJ), and the mean distance from the central groove of central fossa to furcation and the central groove of central fossa to the pulp chamber’s roof was $8.37 \pm 0.33$ mm and $3.87 \pm 0.29$ mm, respectively. The average distance of the pulp chamber’s floor from the furcation was found to be $2.47 \pm 0.11$ mm. The highest degree of variance was observed in case of relation of CEJ to pulp horns, i.e., 44.85% and 82.60%.

Conclusions: The dimensions observed in this study and its resemblance to the various studies reported in literature shift the fundamental anatomic approach to a more systemic quantifiable approach to the endodontic maxillary first molar access preparation.

Keywords: Anatomical landmarks; morphological measurements; pulp space; spiral computed tomography

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INTRODUCTION

Thorough understanding of pulp space morphology and its routinely confronted anatomic variation aids a dentist in attaining successful outcome during endodontic therapy.[1,2] Undesirable results namely accidental pulp exposure during cavity preparation and dentinal gouging, incomplete de-roofing, perforation in the floor of pulp chamber, and missed canals during endodontic procedure could be minimized if we had detailed knowledge about pulp space morphology.[3]

The understanding of location of the anatomical landmarks in the teeth serves as a roadmap that dictates an ideal access cavity which exposes all the pulp canal orifices with the least possible loss of intact tooth structure. These landmarks of significance include central groove of central fossa, cementoenamel junction (CEJ), roof and floor of the pulp chamber, and the furcation. To precisely measure and determine the dimensions of pulp space, newer diagnostic methods such as spiral computed tomography (SCT) are used.

Majority of teeth exhibit variations in anatomy and morphological dimensions of pulp space.[4] Maxillary first molars frequently encounter such variations that often complicate the treatment.[5] Burns reported the maxillary first molar to be “…the frequently treated, minimally apprehended, posterior tooth,”[6]

Hence, the present study was designed to analyze the morphological measurements of anatomical landmarks in human maxillary first molar pulp chambers and evaluation of number of pulp canal orifices using SCT, which would lead us from mystery to mastery of the pulp space of this enigmatic tooth.

SUBJECTS AND METHODS

Sample selection and storage
One hundred and thirty extracted human adult maxillary first molars were collected from the department of oral and maxillofacial surgery. Disinfection procedure included immersing the teeth overnight in 5.25% NaOCl solution and removal of any associated soft tissue debris and calculus using an ultrasonic scaler (Suprasson P5, SATELEC, a company of ACTEON, France), and then, these were stored in 0.9% normal saline solution (Kunal Remedies Pvt. Ltd., Lucknow, Uttar Pradesh, India). Age, gender, and systemic condition of the patient were unknown. Teeth with caries, attrition, prosthesis, metallic restoration, incompletely formed roots, or any fractured or root canal treated teeth were excluded from the study.

Scanning procedure
The teeth were mounted horizontally on a modeling wax sheet (Pyrax Polymars, Roorkee, Uttarakhand, India) in rows of 13 and columns of 5. These teeth were aligned such that the tip of the root apex of teeth in each row was in the same straight plane. A SCT scanner (G.E Brightspeed, Germany) was used to scan 65 teeth at one time. Hence, a total of two scans with 65 teeth each were executed and then analyzed in both axial and coronal views with a standard thickness of 0.65 mm/slice and 0.2 mm/slice, respectively, with a constant spiral speed of 0.75 and 120 KVP. Subsequently, volume rendering and multiplanar volume reconstruction were performed to evaluate the criteria.

Morphological measurements
The scanned data were then transferred to a software named RadiAnt Dicom viewer (4.2.1.17555 Version (64 bit), BUILD DATE- 20-11-17, MACHINE ID- BX2ND-EDFEC-KUXZM-YX9AB-J5PAA), and the imaged picture was morphologically measured. Five direct measures of the selected anatomical landmarks of pulp chambers were measured [Figures 1 and 2] and analyzed for all the teeth:

- **Measurement A**: Number of canal orifices
- **Measurement B**: Distance between CEJ and pulp horns
- **Measurement C**: Relationship of the central groove of central fossa and furcation
- **Measurement D**: Distance between the central groove of central fossa and pulp chamber
- **Measurement E**: Distance between the pulp chamber floor and the furcation.

To assess and evaluate the morphological measurements of pulp space, the middlemost slice in the Dentascan of each tooth was analyzed. A straight line joining the CEJ was extended mesiodistally,[5] and the correlation of the pulp horns to this line was evaluated in the coronal section. To determine the variation in the number of root canal orifices, the axial section of the SCT scan of each tooth was analyzed.
RESULTS

The observed values from our results were statistically analyzed, and kappa value was calculated to test interobserver reliability [Tables 1 and 2]. The kappa value in our study was found to be in the range of 0.810–0.970 which shows that the level of agreement is almost perfect. As per the statistical results reported in our study, there was no significant difference ($P > 0.08$) in the mean and standard deviation between the two observers.

DISCUSSION

Human pulp space shows great variations in terms of shape, size, and configurations. A comprehensive understanding of the pulp space morphological measurements, its variations, proper access preparation, and a thorough exploration of the tooth’s interior and its anatomical landmarks are imperative to achieve desirable results during conservative and endodontic therapy.

Through this study, an attempt was made to reduce the common errors in maxillary first molars such as accidental pulp exposure, loss of sound tooth structure during restorative treatment and perforation, dentinal gouging, and missed canals during endodontic therapy via proper understanding of morphological measurements of anatomical landmarks. Hence, procurement of sound knowledge about the depth of the pulp chamber is considered to be the foremost step for accurate access cavity preparation in multirooted teeth, mainly maxillary first molars. In cases where pulp chamber is calcified leading to reduction in tactile sensation, morphological measurements of pulp chamber would be greatly helpful to the dentist while endodontic therapy.

The prevalence of additional root canals and variation in pulp space morphology has been reported and discussed by several authors. There are varied means that have been utilized to analyze and evaluate the pulp space, namely two-dimensional (2D) radiographs and sliced specimens. However, the radiographs fail to reconstruct a 2D figure into a 3D object and cause anatomic noise and geometric distortion. Smith states that in certain cases, a good-quality radiograph sometimes gives a vague estimation about the dimensions of pulp space. The sliced specimen in a serial sectioning technique often has a disadvantage of causing unreparable damage to the sample. The tooth is made up of hard and soft tissues possessing different radiographic densities, and this makes it possible to assess it using tomographic techniques. The emergence of the 3D imaging has offered the endodontist with advanced diagnostic aids for successful assessment of pulp space morphology that were unavailable to the clinician earlier and made enhancement of the area of interest of an image to be possible. The use of SCT to analyze the pulp space has been seen to impart more desirable results than other aids such as radiographic imaging and serial sectioning.

Table 1: Representing the incidence of number of canal orifices

| Number of canal orifices as observed by both observers | Number of teeth (%) |
|--------------------------------------------------------|---------------------|
| 3                                                      | 40 (30.77)          |
| 4                                                      | 90 (69.23)          |
| Total                                                  | 130 (100)           |

Table 2: Interobserver comparison of morphological measurements

| Variables | 1st observer | 2nd observer | $\kappa$ |
|-----------|--------------|--------------|----------|
|           | Mean±SD      | CV (%)       | Mean±SD  | CV (%)  |          |
| Distance between CEJ and pulp horns (mm) MPH (B) | 0.80±0.36   | 44.85      | 0.79±0.36 | 45.57    | 0.970     |
| Distance between CEJ and pulp horns (mm) DPH (B) | 0.41±0.34   | 82.60      | 0.41±0.34 | 82.93    | 0.895     |
| Distance between central groove of central fossa and furcation (mm) (C) | 8.37±0.33   | 3.88       | 8.36±0.32 | 3.83     | 0.810     |
| Distance between central groove of central fossa and roof of pulp chamber (mm) (D) | 3.87±0.29   | 7.62       | 3.86±0.3  | 7.77     | 0.880     |
| Distance between floor of pulp chamber and furcation (mm) (E) | 2.47±0.11  | 4.61       | 2.46±0.11 | 4.47     | 0.871     |

CEJ: Cementoenamel junction, MPH: Mesial pulp horn, DPH: Distal pulp horn, SD: Standard deviation, CV: Coefficient of variance
Hence, in our study, we used SCT to measure and assess the pulp space of maxillary first molars. Samples in our study were viewed under two sections, i.e., axial and coronal for convenience of a clinician.

As per our results, maxillary first molar exhibits four canal orifices in 69.23% cases and three canal orifices in 30.77%, depicting frequent occurrence of MB2 in maxillary first molars. Stropko in 1999 reported the presence MB2 canal to be in 802 (73.2%) first molars.[18] In maxillary molars, locating and efficiently treating the MB2 canal are necessary. A missed canal if remains untreated may lead to treatment failure. Dow and Ingle observed a failure rate of 2.88% due to undetected canals during root canal procedures.[19] Kulild and Peters found the maxillary first molar among all the posterior teeth to be associated with the highest failure rate, probably because of the presence of a fourth canal in most cases.[20]

In a study by Deutsch and Musikant, the pulp chamber roof was found at the same level as the CEJ in about 98% of cases.[21]

From our study, in majority of the specimens, the roof of the pulp chamber was at a distance of 0.41–0.80 mm coronal to the CEJ. This difference in the dimensions might be ascribed to (a) the deposition of secondary dentin leading to the change in measurements of pulp space and (b) the age of the patient. In case of attrition or fractured cusps during access opening, the endodontist can use CEJ as an authentic anatomical landmark for assessing the depth of the access cavity.[7] In our study, there was difference in the extent of mesial pulp horn and distal pulp horn in relation to CEJ. Mesial horn was higher in majority of samples; thus, the chances of pulp exposure in Class II mesio-occlusal cavity preparation are greater.

We preferred the central groove of central fossa as the main anatomical landmark because this is the point from where we begin access cavity preparation.[11] As per the results from our study, it can be inferred that during access opening, the utmost depth to which a bur can go without breaching the furcation is 5.9 mm (i.e., distance between central groove of central fossa to pulp chamber floor) in the maxillary first molar. In case if the bur go beyond 8.3 mm (Mean distance between central groove of central fossa and furcation), there can be perforation or gouging of the floor of the pulp chamber; therefore, having the markings affixed on the access opening burs, like in rotary files, may prove to be a reliable sign for the operator during access opening. It can greatly decrease the incidence of errors like furcal perforation.

**CONCLUSIONS**

Therefore, many errors while locating the canal orifices in the floor of pulp chamber during endodontic therapy or others such as accidental pulp exposure while executing conservative procedures can be overcome if a clinician has a requisite understanding of the morphological dimensions of pulp chamber. The results obtained in this study and its likeness to the measurements reported in other studies[5,21-23] may serve as a guide that offers a more quantitative approach to maxillary first molar access cavity preparation.

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**Conflicts of interest**

There are no conflicts of interest.

**REFERENCES**

1. Vijayakumar R, Selvakumar H, Swaminathan K, Thomas E, Ganesh R, Palanimuthu S. Root canal morphology of human primary maxillary molars in Indian population using spiral computed tomography scan: An in vitro study. SRM J Res Dent Sci 2013;4:139.

2. Friedman S. Prognosis of initial endodontic therapy. Endod Topics 2002;2:59-68.

3. Khajastepour L, Rahimizadeh N, Khayat A. Morphologic measurements of anatomic landmarks in pulp chambers of human first molars: A study of bitewing radiographs. Iran Endod J 2008;2:147-51.

4. Tomazinho FS, Baratto-Filho F, Zaitter S, Leonardi DP, Gonzaga CC. Unusual anatomy of a maxillary first molar with two palatal roots: A case report. J Oral Sci 2010;52:149-53.

5. Reuben J, Velmurugan N, Kandaswamy D. The evaluation of root canal morphology of the mandibular first molar in an Indian population using spiral computed tomography scan: An in vitro study. J Endod 2008;34:212-5.

6. Burns RC. Access openings and tooth morphology. In: Cohen S, Burns RC, editors. Pathways of the pulp. 4th ed. St. Louis, MO: The CV Mosby Co.; 1987:p.120-1.

7. Krasner P, Rankow HJ. Anatomy of the pulp-chamber floor. J Endod 2004;30:5-16.

8. Vertucci FJ. Root canal morphology and its relationship to endodontic procedures. Endod Topics 2005;10:3-29.

9. Monika RD, Dhawan S, Mehta P. Analysis of root canal anatomy & Morphological variations of maxillary 1st molar by different methods-an in vitro study. J Endod 2014;36:279-85.

10. Mjör IA. Pulp-dentin biology in restorative dentistry. Part 7: The exposed pulp. Quintessence Int 2002;33:113-35.

11. Alhadainy HA. Root perforations. A review of literature. Oral Surg Oral Med Oral Pathol 1994;78:368-74.

12. Goon WW, Lundergan WP. Redemption of a perforated furcation with a multidisciplinary treatment approach. J Endod 1995;21:576-9.

13. Selvakumar H, Kavitha S, Vijayakumar R, Eapen T, Bharathan R. Study of pulp canal morphology of primary mandibular molars using spiral computed tomography. J Contemp Dent Pract 2014;15:728-9.

14. Gupta D, Grewal N. Root canal configuration of deciduous mandibular first molars – An in vitro study. J Indian Soc Pedod Prev Dent 2005;23:134-7.

15. Smith BGN. Planning and making crowns and bridges. 3rd ed. London, UK: Martin Dunitz; 1998.

16. Nair MK, Nair UP. Digital and advanced imaging in endodontics: a review. J Endod 2007;33:1-6.

17. Kummer TR, Calvo MC, Cordeiro MM, de Sousa Vieira R, de Carvalho Rocha MJ. Unusual anatomy of a maxillary first molar with two palatal roots: A case study. Endod 2014;26:279-85.

18. Kulild JC, Peters DD. Incidence and configuration of canal systems in bicuspids. J Endod 2005;31:570-3.