

Morphological Measurements of Anatomic Landmarks in Human Maxillary and Mandibular Molar Pulp Chambers

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The aim of this in vitro study was to measure critical morphology of molar pulp chambers. One hundred random human maxillary and mandibular molars (200 teeth in total) were used. Each molar was radiographed mesiodistally on a millimeter grid. Using a stereomicroscope, the measurements were read to the nearest 0.5 mm. Results were as follows (mean, mm): pulp chamber floor to furcation, maxillary = 3.05 ± 0.79 , mandibular = 2.96 ± 0.78 ; pulp chamber ceiling to furcation, maxillary = 4.91 ± 1.06 , mandibular = 4.55 ± 0.91 ; buccal cusp to furcation, maxillary = 11.15 ± 1.21 , mandibular = 10.90 ± 1.21 ; buccal cusp to pulp chamber floor, maxillary = 8.08 ± 0.88 , mandibular = 7.95 ± 0.79 ; buccal cusp to pulp chamber ceiling, maxillary = 6.24 ± 0.88 , mandibular = 6.36 ± 0.93 ; and pulp chamber height, maxillary = 1.88 ± 0.69 , mandibular = 1.57 ± 0.68 . The pulp chamber ceiling was at the level of the cemento-enamel junction in maxillary, 98%, and mandibular, 97% of the specimens. The measurements showing the lowest percentage variance were buccal cusp to furcation (approximately 11%) and buccal cusp to pulp chamber ceiling (approximately 14%). The measurements were similar for both maxillary and mandibular molars.

One of the irreversible complications of endodontics is perforation into the furcation while gaining access to the pulp chamber of molar teeth. Perforations can sometimes be repaired but often result in extraction of the tooth (1). Access preparations are performed by a qualitative method involving the clinician's tactile perception and knowledge of dental anatomy. However, a reliance on tactile perception alone may lead to undesirable results, including perforation of the pulp chamber (2). Calcification of the pulp cavity may reduce tactile perceptions, possibly leading to perforation of the furcation floor and an iatrogenic failure (3, 4). In this situation, the pulp chamber roof and floor approximate each other,

and perforation may result when the bur traverses the relatively thin floor.

A review of the dental literature regarding the morphology of the pulp chamber revealed very little information. Comparatively few studies describe the morphology of the furcation as it relates to the floor of the pulp chamber. One study measured the distance from the floor of the pulp chamber to five predetermined sites on the furcation root surface and found it to range from 2.7 to 3.0 mm for both mandibular and maxillary molars (5). Another study reported that the mean distance from the pulp chamber floor to the root separation of maxillary molars was equal to or less than 3 mm in 86% of the teeth measured (6).

Clearly, knowledge of the general location and dimensions of the molar pulp chamber may reduce perforations of the chamber during the access process. However, few studies have evaluated external anatomical landmarks as predictors for location of the roof and floor of the pulp chamber. Therefore, the aim of this experiment was to measure key external anatomical landmarks relating to pulp chamber morphology in maxillary and mandibular molars.

MATERIALS AND METHODS

One hundred random human mandibular and maxillary molars (200 teeth in total) were used in this study. The samples were gathered from oral surgery and denture center practices. No teeth were crowned, but some teeth contained caries, restorations, or both. No tooth was used if the caries and/or restorations violated the pulp chamber. The age, gender, and systemic condition of the patients were unknown. Every tooth had a closed apex, and the number of third molars was limited to nine mandibular and 10 maxillary teeth.

Each tooth was mounted with wax on a periodontal millimeter X-ray grid. The teeth were mounted perpendicular to the grid in a mesiodistal direction. This is the same radiographic orientation that would be recorded in vivo. The radiographs were taken on the molar setting with a numerical value of 25 (Heliodent; Siemans). Each radiograph was developed in an automatic developer (Air Techniques, Farmingdale, NY). Each radiograph was examined using a Bausch and Lomb (Rochester, New York) stereoscopic microscope using a magnification of $10\times$. The measurements were recorded to the nearest 0.5 mm. One evaluator examined and made all measurements.

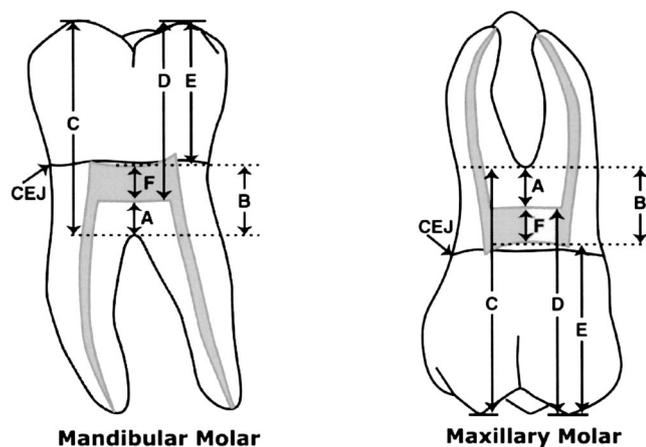


Fig. 1. Location of Measurement for Maxillary and Mandibular Molars.

TABLE 1. Mean measurements (mm) for maxillary molars

n = 100	A*	B	C	D = (C - A)	E = (C - B)	F = (B - A)
Mean	3.05	4.91	11.15	8.08	6.24	1.88
SD	0.79	1.06	1.21	0.88	0.88	0.69
% Variance	25.8	21.6	10.9	10.9	14.11	36.5

* Values A-F refer to measurement distances illustrated in Fig. 1. (%CV = [SD/Mean] and are a measure of the percent variance observed in the sample.

A drawing of the location of the measurements for maxillary and mandibular molars can be seen in Fig. 1. Three direct measurements were taken of each tooth. Measurement A represented the distance between the floor of the pulp chamber and the closest point to the furcation. Measurement B was the distance from the ceiling of the pulp chamber to the closest point to the furcation. Measurement C was the distance from the buccal cusp tip to the closest point to the furcation. B-A represents the height of the pulp chamber. C-A measures the distance from the buccal cusp to the pulp chamber floor and C-B represents the distance from the buccal cusp to the pulp chamber ceiling. It was also noted whether the pulp chamber ceiling was located at the level of the cemen-toenamel junction.

RESULTS

The mean, SD, and coefficient of variation for each measurement are presented for both maxillary molars (Table 1) and mandibular molars (Table 2). It should be noted that means for all the measurements are very similar.

The pulp chamber ceiling was found at the level of the cemen-toenamel junction in maxillary molars in 98% of the specimens and in mandibular molars in 97% of the specimens.

DISCUSSION

A review of the endodontic literature contains relatively few studies that actually measure anatomic landmarks relating to the pulp chamber. Great variance in overall molar tooth size, morphology, and arch position may have led to the assumption that the dimensions of the pulp chamber would also show such great variability that these measurements would be clinically useless. In this study, we measured variance as a percentage of the mean (i.e.

TABLE 2. Mean measurements (mm) for mandibular molars

n = 100	A	B	C	D = (C - A)	E = (C - B)	F = (B - A)
Mean	2.96	4.57	10.9	7.95	6.36	1.57
SD	0.78	0.91	1.21	0.79	0.93	0.68
% CV	26	20	11.1	9.94	14.6	43

* Values A-F refer to measurement distances illustrated in Fig. 1. (%CV = [SD/Mean] and are a measure of the percent variance observed in the sample.

coefficient of variation [CV] = SD/mean). When comparing both maxillary and mandibular teeth, the range of CV values was 10% to 43%. For both maxillary and mandibular molars, the largest CV values were observed for the pulp chamber height (measurement F in Tables 1 and 2). This intertooth variation in pulp chamber height is probably the result of the biologic process of secondary dentin apposition. Several studies suggest that secondary dentin apposition occurs primarily on the pulp chamber floor instead of the ceiling. For example, one study evaluated ancient and contemporary populations and observed no significant changes in the dentin thickness at the roof of the pulp chamber with increasing age, whereas the dentin at the floor of the pulp chamber showed a definite increase in thickness with increasing age (7). Another study reported a highly significant reduction in the height of the pulp chamber of the mandibular first permanent molar (15%) that was caused mainly by an increase in thickness of the pulpal floor (8). Tidmarsh (9) stated that "the growth of dentin upon the floors of pulp chambers, apparently without cause, is of some significance to the endodontist who must gain entrance to the root canals."

Because this is a radiographic study, it is possible that variation in radiographic measurement versus anatomic measurement could be responsible for variation between groups. However, Scotti et al. (10) demonstrated that the residual error between the anatomic and radiographic measurement was 4.46%, which, when extrapolated to our data, is equivalent to an average difference of 0.12 mm. This number is smaller than all of the measured SDs; thus, we do not believe that this theoretical problem confounds our results.

The results of this study agree with the measurements reported in two other studies. Sterrett et al. (5) reported that the average distance from the pulp to the root surface (furcation) was 2.83 mm (SD of 0.49) for mandibular first molars and 2.88 mm (SD of 0.44) for mandibular second molars. Majzoub and Kon (6) measured maxillary molars and found that the distance from the pulp chamber floor to the most coronal aspect of the area of root separation (furcation) on the distal aspect was equal to or less than 3 mm in 86% of the teeth measured. In this study, we reported pulp floor to furcation measurements in maxillary molars of 3.05 mm (SD of 0.79) and in mandibular molars of 2.96 mm (SD of 0.78).

Other studies have measured the relation between external landmarks and pulp chamber locations. One study measured the distance from each cusp tip to the corresponding height of the pulp chamber ceiling and reported mean distances for maxillary first molars (5.77 mm), maxillary second molars (5.66), mandibular first molars (6.42 mm), and mandibular second molars (6.24 mm) (11). These values are similar to those obtained in the present study (Tables 1 and 2).

The reported measurements in this study and their similarity to measurements from other studies give us a general guideline for a more quantitative approach to endodontic molar access. In general, the distance from the cusp tip to pulp chamber ceiling height is approximately 6.0 mm, the distance from the pulpal floor to the

furcation is approximately 3.0 mm, and the average height of a pulp chamber is 1.5 to 2.0 mm. In addition, the pulp chamber ceiling was found at the level of the cemento-enamel junction in 97% to 98% of the maxillary and mandibular molars. This knowledge of pulp chamber morphology should be integrated with an examination of preoperative radiographs (to assess for other potential factors such as taurodontism (12)) and intraoperative tactile perception during endodontic access preparations.

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