

Variations in Morphology of Permanent Mandibular First Molar - A Cross-Sectional Study with Radiographic Assessment

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Abstract: *The present study attempted to address the variations of permanent mandibular first molars in terms of its dimensions, morphology of crown and root (shape, number and its configuration), morphology of pulp in crown and root, canal calcification, root curvatures.*

1. Introduction

Permanent mandibular first molars are considered stable in morphology and hence are referred as key teeth; however they display several anatomical variations.¹⁻⁵ Functionally, permanent mandibular first molars (PMFM) play a principal role in mastication and help to maintain vertical dimension of the face, continuity of the dental arch, maintain the cheeks and tongue in position.^{1,2,4,6} It is not rare to find morphological variations in dimensions, number of cusp and root, number of canals, canal configurations, shape of tooth, pulp chamber and root canals.

Being the earliest tooth to erupt, mandibular 1st permanent molar is often affected by dental caries and usually needs root canal treatment.⁸⁻¹⁰ Several studies have been performed to assess the variations in root and root canal system, the studies were conducted either in vitro on extracted teeth or in vivo on the patient using various methods such as radiological, clearing technique, stereomicroscopy, computerized tomography imaging.

The presence of an extra root, may make extraction and orthodontic tooth movement difficult¹⁵. Radix Entamolaris rendering poor oral hygiene, food impaction, and short root trunk is contributing factor in localized periodontitis¹³. The etiology of such variations is unknown, but it is believed, that mutated genes which encode transcription factors and signaling molecules which are involved in odontogenesis could be responsible.^{2,21}

In view of the numerous variations, it essential to be diligent towards the morphological variations associated with this tooth.

2. Review of Literature

Wheeler (2009)²² and Ingle J (2008)²³ describe the dimensions of PMFM as crown length 7.5 mm, root length 14.0 mm and mesio-distal width of crown as 10.5 mm. It usually has 4 pulp horns, the shape of pulp chamber is quadrilateral, the pulpal floor is trapezoidal or rhomboidal

and pulp canals are smooth and tapered.

Mayhall (2000)³⁵ and Moreno et al (2004)³⁶ found the variations in number of cusps being 6-7 in number. The extra sixth cusp was called 'tuberculum accessorium posterior internum' and is usually located between the distolingual and the distobuccal cusps of primary and permanent mandibular molars. It has been described as a racial characteristic of Mongoloid populations by Moreno (2005) and the frequency of such characteristic was 5%.³⁷ The other accessory molar cusp, the 7th cusp, termed as 'tuberculum accessorium mediale internum', is located at the marginal border between the mesiolingual and distolingual cusps.²⁴

The incidence of three-rooted mandibular first molars such as radix entamolaris and radix paramolaris were found to be a common feature. A supernumerary root, located distolingually, is called Radix Entamolaris, and root located distobuccally is called as Radix Paramolaris.^{11,12,20} Ferraz & Pecora (1992) observed a prevalence of 3-rooted mandibular 1st molars to be 2.8% for Black origin and 4.2% in Caucasian population²⁷. The incidence for same in Indian population was reported as 5.97% by Garg et al (2010)³⁸. Kottor et al (2010)⁴³ also mentioned a case with occurrence of 4-rooted first molar. In general, the prevalence of three-rooted molar was variable ranging from 0.91 to 40% in previous studies.¹⁶⁻²⁰

Root canal morphology and configuration has been classified by Weine et al (1969)³⁹, Vertucci (2006)⁴⁰ and Gulabivala et al (2001)⁴¹. Krasner and Rankow (2004)³⁴ found two orifice openings at the pulpal floor. The two roots may have an 'extra' canal against the usually found 2 canals. Often, this may be in the mesial root, therefore containing three canals, called the middle mesial canal (MMC).²⁴ Cases of an additional canal in distolingual position, three canals in distal, four in mesial root or one canal in each root have also been reported.^{43,45} DeMoore et al and Walker R observed 3 root canals in distal root with incidence of 47.6%.^{2,46} Reichart PA & Pattanshetti N reported the presence of three canals in the distal root.^{4,47} Martínez-Berná A and Badanelli P (1985) found 4 canals in distal root.⁴⁸ A case of molar with

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seven canals was reported by Banode et al (2016).⁴⁴

Tabulated year wise incidences of variations in the root & canal morphology have been presented through systematic reviews.^{6,42} Ballulaya et al (2013)⁶ reported the incidence of 3-rooted molars was 3-33% and of third canal in mesial root was 0.9-15%. Pablo et al (2010)⁴² reports 13% incidence of three-rooted molars, 61% for 3 canals and 35.7% for 4 canals.

Through the literature search, it was observed that over 95% studies were related to variations in root, root canal system and its endodontic considerations. It was scanty on the variations in the crown morphology.

3. Aims and Objectives

The aim of this study was to establish the prevalence of variations in the morphology of permanent mandibular first molars in a population of Vidarbha region. The objective was to derive the proportion of variations i.e. the number of subjects showing each variation amongst the study population.

4. Methodology

This ethics committee approved study was carried out in the outpatient department in a private dental college in Vidarbha district of Maharashtra. The present cross-sectional study included 1250 subjects with males and females approximately in equal proportion in the age range of 6 to 75 years sorted by simple random sampling.

IOPAs were used as a source of information for the study because they are most commonly advised investigation for a patient. Active patient consent was obtained and only those IOPAs that were advised for them as a part of their treatment were included in the study. Radiographs are a reliable source of information as they show the detailed morphology of parts of the tooth and also the root canals can be easily assessed. Basic knowledge of the different radiopaque and radiolucent structures visible on an IOPA interpretation is required to do so.

On collecting the radiographs, the radiographic assessment for the variations in morphology was done under ideal viewing conditions with the viewer kept in dim light. The viewer used was with uniform illumination all over the viewer screen and the use of magnifying lens was essential, especially to visualize the number of pulp and canal anatomy.

The morphological variations were assessed as per the following criteria:

- 1) Variation in dimensions in millimeter (mm)
 - Crown length
 - Mesio distal width of crown
 - Root length
- 2) Variation in anatomy
 - Shape of cusp
 - Number of cusps
 - Shape of root

- Number of root
 - Shape of pulp chamber
 - Shape of root canal
- 3) Presence of supernumerary root
 - 4) Presence of additional canal
 - 5) Canal calcification
 - 6) Root curvatures
 - 7) Any other

The prevalence (number and the percentage of subjects) of each finding was tabulated and subjected to statistical analysis to reach to the results and observations about the study population.

Statistical Analysis

The analysis is done using 22.0 SPSS software. For all the observations, the p-value of less than 0.05 was taken as significant. The differences in the mean values of dimensions were assessed by t-test. The comparisons of the variables according to gender and side of PMFM were done using Chi-square test.

5. Observation and Results

The total of 1250 study subjects was divided according to decade to form the 8 age ranges. It was observed that higher numbers of subjects were present in 2nd, 3rd and 4th decade of life.

The mean values of the dimensions of PMFM as crown length (CL), mesio-distal width of crown (M-D) and root length (RL) were calculated. Males showed higher mean values than females in all the dimensions. While comparing the dimensions of PMFM according to gender, the mean differences were significant for mesiodistal width and for root length.

When the study subjects were compared according to gender, significant differences were noted with variation of number of cusps between male and female, instead of 5 cusps that are present normally, they showed 4 cusps; however for rest of the variations, differences were not significant. At similar, the differences did not reach to the level of significance when study subjects were compared according to the side of PMFM.

6. Discussion

The present study included total 1250 subjects with comparable gender distribution. Most of the previous studies included the sample size of less than 1000, this one of the few studies with significant sample size and the subjects over wide age range. The sample also included the comparable distribution of both sided first molars in the sample.

This study is based on the radiographic assessment of study subjects using intraoral periapical radiographs (IOPA). IOPA is commonly taken for the patients in OPD hence there was no need to separately expose the patient to investigation. Thus, being one of the simple, non-invasive, economic and safe methods of assessment of molar

dimensions and morphology as compared to computerized tomography which leads to high radiation exposure to the subjects. This allows the in vivo molar assessment against the in vitro studies performed earlier on the extracted teeth.⁵⁻⁸

The mean values (\pm SD) of the dimensions of PMFM as crown length (CL), mesio-distal width of crown (M-D) and root length (RL) were found to be comparable to that shown by Wheelers and Ingle J.^{23,49} Males showed higher mean values than females in all the dimensions. While comparing the dimensions according to side of PMFM, the mean differences were insignificant for all the dimensions which was in accordance with earlier observations that the right and left sided molars are usually symmetrical.⁵⁰⁻⁵²

The current research has included all possible variations that could be observed in PMFM. Considering the anomalies in the shape and number of cusps, the shape of the cusp was conical in all the subjects. For the number of the cusps, it was observed that total 18 (1.1%) subjects showed only 4 cusps in place of 5 cusps. One male subject manifested with multiple small cusps and 1 female subject showed PMFM with 5 cusps in circular arrangement than quadrilateral pattern of cuspal arrangement that is usually seen. Previous related study showed higher incidence of 8.7 % of molars with 4 cusp, 6.95% with 6 cusp and 11.75% with 7 cusps.⁵³ Bansal and Ajwani also mentioned about presence of extra distal cusp on PMFM.⁹ In 5 (0.3%) subjects, the roots were rounded or bulbous in place of normal tapered apically constricted roots.

The shape of the pulp chamber and root canal were normal as quadrilateral and tapered respectively for most of the study subjects. For mesial root, the root canal was found to be curved while for the distal root, it was found to be broader and straight in the course as compared to mesial root. The variable amount of secondary dentin deposition with aging makes the pulp cavity narrow gradually.⁸ In the population, 4 (0.4%) subjects showed very long pulp chamber and small root canals as in taurodont.

The variations were also observed in the number of roots, PMFM normally has 2 roots placed mesially and distally. The occurrence of 3-rooted PMFM was first described by Turner CG in 1971.⁵⁴

There were 2 (0.2%) molars with one root and 04 (0.2 %) molars with 3 roots, in 2 cases they were placed lingually as Radix entomolaris. It has an occurrence of less than 5-6.4% in the Indian population.⁵⁵ The prevalence of 3-rooted molar was observed to be 1.44% (Shahi et al), 2.02% (Vertucci) and 13% in Thai population by Gulabivala et al.^{16,19,41}

The gender wise and the side wise incidences of the extra root were variable in the previous studies, at similar the present study did not show any significant differences in their prevalence when compared according to gender or side of PMFM. In the present study, when prevalence were compared according to gender, it was found to be 0.2 % in males and 0.1 % in females which is very less than that observed in earlier studies as 0.3% in males and 0.6% in females (Bansal et al), 1.5% in males and 21% in females

(Sujatha et al).^{9,56}

When compared according to side of PMFM, the prevalence of 0.1 % for right side and of 0.2% for left molar was observed. This was comparable to 0.5 % and 0.4 % (Bansal et al) and 2.4% and 0.4% (Goel et al).^{9,57} While it was too less as compared to that shown by Sujatha et al as 5 % in males and 10 % in females.⁵⁶

Radix Entomolaris is first mentioned in the literature by Carabelli in 1844.⁵⁷ Some studies also supported the bilateral occurrence of radix entomolaris.⁵⁵ The prevalence in the range of 3-5% was observed in Europeans, Africans, Eurasians and Indians while of 5-40% was found in Eskimos, Chinese and American Indians. Apart from having the clinical significance, radix entomolaris also has a role as genetic marker.⁶ The extra small root located buccally is known as radix paramolaris, some of the authors reported it to occur in PMFM.^{2,59}

The etiology in formation of radix remains unclear. In dysmorphic supernumerary roots, it could be related to external factors encountered during odontogenesis or presence of an atavistic gene or polygenetic system. Its severity depends on the formation stage of the involved teeth.

In the present study, the prevalence of extra canals was found to be 1.9 % as 32 subjects showed additional canals. Out of these 32, 26 subjects had 3 mesial canals, 2 had 4 mesial canals and 2 subjects had 3 distal canal. This is corresponding to study by Fabro-Campos H (2.1-2.6%) and 1-20% by Baugh and Wallace.^{26,60}

Overall the prevalence of extra canals ranged from 0.9-59%.⁵⁰ Ballulaya et al found it to be in the range of 0.9-15%.⁶ De Moore et al and Walker T observed 3 root canals in distal root with incidence of 47.6 %.^{2,20} Ahmed SA found it to be as high as 59%.⁶¹ A radiographic study by Goel NK et al performed on extracted teeth reported mandibular first molars with three mesial canals in 13.3%, four mesial canals in 3.3%, and three distal canals in 1.7% of specimens.⁶²

This study also analyzed root curvatures or dilacerations which was observed in total 23 (1.4%) subjects with prevalence of 0.5% in males and 0.9% in females. In side wise comparisons, it was found to be 0.7 % in right-sided and 0.7 % in left sided molar. Mostly, the roots with dilacerations were curved in distal directions in 91 % cases. Gu Y et al emphasized the importance of root canal curvatures stating the degree of curvatures.¹

This study estimated the prevalence of canal calcification in roots which was observed to be 2.5% (42 subjects) as whole being 1.5% in male and 1.0% in females. This was found to be in very negligible proportions. The canal calcifications were observed more in elderly population and amongst 42 subjects who showed it, in 82.7% cases mesial canal was involved and the rest 11.3% cases showed distal canal calcifications. Overall, 5.5% cases, canal showed the total calcification involving the root from cervical to apical third with no root canal evident. Again, very scanty literature is available on estimation of canal calcification in PMFM.

Overall, the estimated prevalence of variations in the present study was found to be lower as compared to previous studies. Although the wide range of prevalence was found in the literature, this may be attributed to the racial or ethnic differences or genetic predilections for these variations. In general, except for the dimensions, all other observations were incomparable. The present study has included the significant magnitude of sample as compared to other studies, but still the results warrants for the further study with broader representation of the population.

7. Conclusion

The aim of the present study was to establish the prevalence of variations in morphology of PMFM in study population. Overall, the prevalence of the anomalies was found to be in the range of 0 to 2.5%. This was comparable to few earlier studies; however some of the studies had exaggerated prevalence which was linked to genetic, ethnic or racial differences as well as differences in methodologies and sample size etc.

This is one of those few studies that have addressed all possible variables related to permanent mandibular first molar including the significant sample size. The hard tissue repository and soft tissue of the human teeth takes on various configurations and shapes.

Oral health physician must be thorough with variations of crown, root and complex root canal system of permanent mandibular first molar.

Knowledge of both normal and abnormal anatomy of mandibular molars is essential for execution of successful root canal therapy.

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