ABSTRACT

The aim of the present work is to study the External and Internal Root anatomy of Egyptian Maxillary First Permanent Molar. 180 maxillary first permanent molar were randomly selected with intact roots, minimal occlusal decay, and without fillings. External morphological observations of roots were recorded including the number of roots, root trunk length, Maximum convexity level and the relation of root apices to cusps or grooves on the crown. The number of root canals per root and the presence of lateral canals were also recorded. The measures were recorded and compared with similar studies done on other populations and compared also to those mentioned in some of the text books. From the results it was concluded that within the same population there is a range of differences in measures and relations between individuals yet still there are common features that usually characterize a population from another which could be related to the genetic factors.

INTRODUCTION

Studying the internal and external anatomy of the permanent teeth specially the permanent molars has been the main scope of many morphological and morphometric studies in different populations. A number of studies have shown different trends in the shape and number of roots and canals amongst different races. In the beginning of 20th century, Okmura published his revolutionary study about the transformation of teeth into transparent blocks. When compared between clearing and radiographic techniques in studying the root canal anatomy, it was proven that the clearing technique is of considerable value in viewing the canal’s system anatomy in three dimensions in invitro studies.

The importance of studying the dimensions, external and internal anatomy of the roots has been expressed in many studies. Interestingly the morphology of molar roots and the furcation region have been described to influence both pathogenesis of periodontal destruction and treatment of furcation involved molars. Also Hou and Tsai reported that the great variability in root trunk dimensions and narrow furcations in 2nd molars placed them at great risk of periodontal problems than 1st molars in Chinese population. Tauby et al., confirmed that before endodontic therapy is performed, the clinician should know the number of roots and canals, as well as external and internal anatomy of the tooth that is to be treated. False assumptions about root and root
canal morphology may lead to incomplete debridement and obturation of canal space and can eventually lead to failure of treatment.

From the previous data the idea of this invitro study was carried out to investigate root morphology, configuration and the number of root canals and their anatomical variations in the upper first permanent molars in the Egyptian population.

**MATERIALS AND METHODS:**

1) **Sample Collection:**

A total of 180 maxillary first permanent molar were randomly selected from a collection of extracted teeth from adult Egyptian patients seeking dental treatment in both: Faculty of Dentistry, Ain Shams University and Cairo University.

The collected teeth were selected with intact roots, minimal occlusal decay, and without fillings. Teeth were fixed in 10% formalin, and then were placed in 3% sodium hypochlorite for 3 hours to remove remaining soft tissues. Teeth were then cleaned from any calculus to be ready for inspection.

2) **Recording External Root Anatomy Results:**

A photographs of each examined tooth together with a piece of a graph paper were taken by a digital camera (Canon, Power Shot A430,4.0Mega pixels ). The graph paper was used to adjust the scale for the image analysis software (Image J 1.34(NIH,USA)) used for recording the measures. Such a way allowed standardizing the scale of measures for all measured teeth.

External morphological observations of roots were recorded by stereomicroscope in the Oral Pathology Department, Faculty of Dentistry, Ain Shams University, as follows:

a. Recording the number of roots including bifid roots.

b. Root length and root trunk length from buccal, mesial and distal aspects of maxillary first molar.

c. Maximum convexity levels were detected, for the mesiobuccal and the palatal root of maxillary molars from the mesial aspect and for the buccal roots of the same teeth in relation to crown boundaries from the buccal aspect. The distobuccal root maximum convexity was detected from the distal aspect. This was achieved by extending tangential lines from maximum convexities of the roots and comparing them with the maximum convexities of the crowns.

d. Relation of root apices to cusps or grooves on the crowns through extending straight lines from root apices to the crowns.

3) **Studying Root Canal Morphology:**

This was achieved by using canal staining and tooth clearing technique. At first, access cavities were prepared and pulp tissues were extirpated and removed using 5.25% sodium hypochlorite solution. Teeth were stored in 5% nitric acid solution for 5 days for decalcification. Then rinsed under running water for 4 hours and placed in increasing concentrations of ethyl alcohol. Teeth were rendered clear by immersing them in methyl salicylate solution for 3 days until complete transparency was achieved. Following this procedure, India ink was injected in root canals. Under magnification (X3), the following features were evaluated:

i) Number of root canals per root.

ii) Presence of lateral canals.

**RESULTS**

180 maxillary first permanent molars were examined and photographed. The following results were detected:

At the cervical line, the crown is attached to a broad undivided base which is the root trunk; the length of root trunks from the buccal, mesial and distal surfaces was measured. The mean and standard deviation were calculated and stated in Table (1). The longest root trunk detected, was the distal root trunk with a mean value of 4.3mm and standard deviation of ±0.7 followed by the buccal root trunk with a mean value of 3.8mm and
standard deviation of ±0.45. Moreover, the shortest root trunk was detected on the mesial surface with a mean value of 3.57mm and standard deviation of ±0.53.

From the root trunk, the root was divided into a number of roots. It was found that 96.7% of the maxillary first molar teeth have three roots, while in 2.2% of cases; the mesiobuccal root was bifid apically. Only 1.1% of cases had two roots, where the distobuccal and palatal roots were fused.

The length of the three roots of the upper first molar was measured from the cervical line till the longest point of the root apex. Mean root lengths and standard deviations were calculated in Table (1). Interestingly, it was found that the palatal root recorded the longest lengths ranging from 12.5mm to 16mm with a mean value of 13.9mm and a standard deviation of ±1.15. While the distobuccal root length was the smallest to be recorded, ranging from 11mm to 15.5mm with a mean value of 12.73mm and a standard deviation of ±1.63. The mesiobuccal root length ranged from 12mm to 16mm with a mean value of 13.53mm and a standard deviation of ±1.14. These results denote that the difference between the mesiobuccal and palatal root lengths was about 1mm in 20% of cases and 0.5mm in 26% of cases. The difference was 2mm between the palatal and the mesiobuccal root lengths in 20% of cases. In 33% of cases the mesiobuccal root showed no difference in length from that of the palatal root. Recorded results also reveal that the mesiobuccal root was longer than the distobuccal root by about 1mm in 40% of cases and 0.5mm in 33% of cases. While in 20% of cases the difference was 1.5mm. In 7% of cases the mesiobuccal root showed no difference in length from that of the distobuccal root.

Inspected from the buccal view, the mesiobuccal root apex of the upper first molar was found to be on one line with the mesiobuccal cusp tip in 60% of the cases (Figure 1). While in 40% of cases it was found on one line with the buccal groove (Figure 2). The distobuccal root apex when inspected from the buccal aspect, in 80% of cases, was distal to the distobuccal cusp tip (Figure 2). While only in 20% of the cases, the distobuccal root apex was on one line with the distobuccal cusp tip (Figure 1).

Concerning the maximum convexity of the mesiobuccal root of upper first molar when viewed from the buccal aspect, it was found to be within the confines of the crown (Figure 1). Only 20% of cases were the same for the distobuccal root. On the other hand, in 80% of cases, the distobuccal root maximum convexity was found to be on one line with the distal outline of the crown (Figure 2). For the palatal root, when inspected from the lingual aspect, in 50% of cases, the root apex was found on one line with the palatal groove of the crown (Figure 3). While in 33.4% of cases, it was distal to the palatal groove (Figure 4). In 16.6% of cases the palatal root apex was mesial to the palatal groove. From the mesial aspect, the mesiobuccal root apex was on one line with the mesiobuccal cusp tip. Its maximum convexity was outside the crown almost in all cases (Figure 5). In limited cases the mesiobuccal root apex was found buccal to the mesiobuccal cusp tip (Figure 6).

The palatal root apex in 80% of cases was palatal to the crown outline. Its maximum convexity, was outside the confines of the crown almost in all cases (Figure 5). In 20% of cases the palatal root apex was within the confines of the crown outline.

**TABLE 1: The Mean and Standard deviation of root and root trunk lengths of the maxillary first molar**

<table>
<thead>
<tr>
<th>Variant</th>
<th>Mesiobuccal root</th>
<th>Distobuccal root</th>
<th>Palatal root</th>
<th>Buccal root trunk</th>
<th>Mesial root trunk</th>
<th>Distal root trunk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>13.53333</td>
<td>12.73333</td>
<td>13.9</td>
<td>3.833333</td>
<td>3.566667</td>
<td>4.3</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>±1.141219</td>
<td>±1.162919</td>
<td>±1.152637</td>
<td>±0.449868</td>
<td>±0.530049</td>
<td>±0.702038</td>
</tr>
</tbody>
</table>
Reham Magdy Ameen and Rania Mossad Hassan

**Fig. (1)** A photograph showing the test lines generated by the computer on the buccal view of the upper first molar. Both the mesiobuccal and distobuccal root apices are on one line with the corresponding cusp tips. The maximum convexities of the two buccal roots are within the confines of the crown.

**Fig. (2)** A photograph showing the buccal surface of the upper first molar. The mesiobuccal root apex is on one line with the buccal groove. Meanwhile the distobuccal root apex is distal to the distobuccal cusp tip. The distobuccal root maximum convexity is on one line with the distal outline of the crown.

**Fig. (3)** A photograph showing the test lines generated by the computer on the palatal surface of the upper first molar. The root apex is on one line with the palatal groove of the crown.

**Fig. (4)** A photograph of upper first molar showing the root apex distal to the palatal groove.

**Fig. (5)** A photograph showing the mesial aspect of maxillary first molar. The mesiobuccal root apex is on one line with the mesiobuccal cusp tip. Its maximum convexity is outside the crown outline. The palatal root apex is palatal to the crown outline. Its maximum convexity, is outside the confines of the crown.
A study on the external and internal root

From the distal aspect of upper first molar, the distobuccal root apex was buccal to the distobuccal cusp tip in about 20% of the cases. The distobuccal root maximum convexity was found outside the crown outline in 35% of the examined cases (Figure 7). The distobuccal root apex was on line with the distobuccal cusp tip in 70%. Its maximum convexity was within the confines of the crown in 50% of the cases (Figure 8). Meanwhile the distobuccal root apex was lingual to the distobuccal cusp tip in 10% of the cases. Its maximum convexity was found inside the crown outline in 15% of the examined cases (Figure 9).

Concerning root canal anatomy of maxillary first molar, approximately all the studied cases showed one root canal in both palatal and distobuccal roots, they just differed in their curvature and width. In 57.7% of studied cases, the mesiobuccal root showed two root canals either end with single apical foramen or 2 separate apical foramina. Meanwhile, 42.3% of cases showed a single root canal in the mesiobuccal which was mostly found to be a wide canal (Figure 7).

From the distal aspect of upper first molar, the distobuccal root apex was buccal to the distobuccal cusp tip in about 20% of the cases. The distobuccal root maximum convexity was found outside the crown outline in 35% of the examined cases (Figure 7). The distobuccal root apex was on line with the distobuccal cusp tip in 70%. Its maximum convexity was within the confines of the crown in 50% of the cases (Figure 8). Meanwhile the distobuccal root apex was lingual to the distobuccal cusp tip in 10% of the cases. Its maximum convexity was found inside the crown outline in 15% of the examined cases (Figure 9).

In one of the variations of the maxillary first molar, the distobuccal root was found with a concave buccal outline and the palatal root showed a palatal inclination without curvature (Figure 10).

Concerning root canal anatomy of maxillary first molar, approximately all the studied cases showed one root canal in both palatal and distobuccal roots, they just differed in their curvature and width. In 57.7% of studied cases, the mesiobuccal root showed two root canals either end with single apical foramen or 2 separate apical foramina. Meanwhile, 42.3% of cases showed a single root canal in the mesiobuccal which was mostly found to be a wide canal (Figure 7).
Teeth have a complex form and when a large collection of dentitions from one species is seen, it shows a surprisingly large degree of variations in form. These variations seem to be relatively a little bit affected by the environment in which growth took place, and in any case disruption to growth can be recognized in affected individuals as developmental defects that deviate from normal. The idea of this study was based on recording measures of roots and root trunks of extracted maxillary first molars, analyzing the relation of root apices, maximum convexities to crown outline and cusp tips, in Egyptian population and comparing these results to those in other populations and text books. Also this study depended on clearing technique to study the root canals morphology. Although various techniques to evaluate canal morphology. It has been reported that the most detailed information can be obtained by this technique of choice in this study which is regarded as a perfect method for three dimensional study of root canal morphology.

Concerning root trunk length of 180 maxillary first molar, most of cases (46%) showed a difference of 1mm between the mesial and distal root trunk. Meanwhile, the extremes, which are 2mm difference or being equal in length, showed the least percentage. The distal root trunk showed the longest length with 4.3mm average length and a standard deviation of ±0.7. The mean buccal and mesial root trunk lengths were about 3.8 and 3.6mm respectively with a standard deviation of ±0.45 and ±0.53. Our measurements of the root trunk length showed that the longest root trunk is on the distal aspect while the shortest is the mesial root trunk. This coincides with the results of Gher & Dunlap, where the mesial furcation was found after about 3.6mm from the cervical line. Meanwhile the distal furcation was found after about 4.2mm from the cervical line and the facial furcation was found after 4mm. Also Major and Marcus, stated that the point of bifurcation of the two buccal roots are located at approximately 4mm above the cervical line. Meanwhile on the mesial aspect, it was stated that the level of bifurcation is a little bit closer to the cervical line than that found between the buccal roots. On the other hand, from the distal aspect, the area from the cervical line to the bifurcation is 4.5mm or more. On recording the number of roots of the maxillary first molar in our study, 96.7% of cases showed three roots, 1.1% showed bifid mesiobuccal root, while 2.2% of cases only showed fusion between the distobuccal and palatal root demonstrating double rooted cases. These results coincide with those done by Cleghorn et al., on root anatomy of permanent maxillary first molar, where 95.5% of cases showed three roots, 3.9% had two roots representing fusion between two roots. Meanwhile, in Jordanian
A study on the external and internal root population, 97 specimens of 100 extracted maxillary first molar showed three roots. Only three specimens showed fusion between two roots. On recording the average lengths of the three roots of the upper first permanent molar, the palatal root demonstrated the longest length with average of 13.9mm and a standard deviation of ±1.15 while the shortest was the distobuccal root with a mean of 12.73mm and a standard deviation of ±1.16. In 33% of cases the mesiobuccal root showed no difference in length from that of the palatal root while in 20%, it showed 2mm difference. In 40% of cases the mesiobuccal root was longer than the distobuccal root by 1mm. These results are in competence with those of Major and Marcus who stated that the average palatal root length was 13mm and the mesiobuccal root length was 12mm with an average difference of 1mm. Meanwhile, it was reported that both buccal roots were approximately equal in length, although there was a considerable variation in this result, where the difference between their lengths was a matter of one millimeter or even a half millimeter. Also these results are not far from those stated by Julian, Woelfel and Rickne, who stated that the three roots of maxillary first permanent molar are nearly the same length.

On judging the maximum convexities of the two buccal roots of the upper first permanent molar from the buccal aspect, in all cases, the mesiobuccal root was found inside the crown outline, while in 20% cases only, the distobuccal root was found as the mesial root. In 80%, it was found to be on one line with the distal outline of the crown. From the mesial aspect, palatal root demonstrated a maximum convexity outside the confines of the crown, in almost all cases. These relations coincide with that stated by Major and Marcus, where it was reported that from the buccal aspect, a measurement of the roots inclusively at their greatest extremities mesiodistally, is less than a calibration of the diameter of the crown.

Dealing with the anatomical relations between crown and root of the maxillary first permanent molar, our results reported that 60% of cases showed that the mesiobuccal root apex was on line with the mesiobuccal cusp tip. Meanwhile in 40% of cases, it was distal to the cusp tip. Also, the distobuccal root apex in 80% of cases was distal to the distobuccal cusp tip and in 20% of cases only; it was on line with the distobuccal cusp tip. Julian, Woelfel and Rickne reported that the palatal root apex of the maxillary first permanent molar is on line with the palatal groove. In our results this was true in 50% of cases while in 33.4%, the palatal root apex was distal to the groove and in 16.6% only; it was mesial to the groove. From the mesial aspect, palatal root apex, in most cases (80%), was found palatal to the palatal outline which also goes with what stated by Julian, Woelfel and Rickne.

In a study done on the maxillary first permanent molar teeth of South Asian Pakistanis population, the mesiobuccal root presented a single canal in 42.3% of cases, while in 57.7%, two canals were found. The distal and palatal roots that contained a single root canal in 100% of cases. In a study on Jordanian population, Smadi and Khraisat observed a high percentage of the presence of two canals in the mesiobuccal root which was about 62.9%. This result coincides with our results which revealed that 57.7% of the mesiobuccal root showed two canals with different configurations. Meanwhile 42.3% showed a single canal in the mesiobuccal root. On the other hand, both palatal and distobuccal roots showed a single canal in 100% of cases. Also these results were concomitant with a study done by Cleghorn et al., who stated that the incidence of two canals in the mesiobuccal root was higher (60.5%) in a laboratory study on cleared teeth. Meanwhile the distobuccal and palatal roots showed a single root canal with a percentage of 98.3% and 99% respectively. Finally within any population there are variations between individuals, so over a range, a feature may take on different forms or its measurable size may vary. Some individuals may have a form or size of this feature that fits within the range found on other populations.
REFERENCES


