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# Evaluation of root morphology and canal configuration of maxillary premolars in a sample of Pakistani population by using cone beam computed tomography

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RESEARCH ARTICLE

# Evaluation of root morphology and canal configuration of Maxillary Premolars in a sample of Pakistani population by using Cone Beam Computed Tomography

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## Abstract

**Objectives:** To evaluate the root canal morphology of maxillary premolars.

**Method:** This retrospective study was conducted from November 2016 to January 2017 at Aga Khan University Hospital, Karachi, and reviewed Cone Beam Computed Tomography images of maxillary first and second premolars done from November 2014 to October 2016. Frequency distribution of Vertucci's classification was determined. Chi square test was applied to determine any association between Vertucci's type and gender. SPSS 19 was used for data analysis.

**Results:** Of the 114 first premolars, 74(68.6%) were bi-rooted and 36(31.5%) were single-rooted. The mean lengths of buccal and palatal roots were 20.6 ±1.7mm and 19.5±2.0 mm, respectively. The most common canal morphology reported for maxillary first premolars was type I 127(68%) followed by type II 24(12.9%). Of the 115 maxillary second premolars, 97(84%) were single-rooted. The mean lengths of buccal and palatal root were 20.7±1.6mm and 19.0±1.45mm, respectively. The most common canal morphology reported for second premolars was type I 71(53.4%) followed by type II 18(13.5%).

**Conclusion:** Vertucci's type I was the most common canal configuration for maxillary first and second premolars and there was no gender-based difference for root canal morphology of maxillary premolars.

**Keywords:** Root canal, Endodontic treatment, CBCT, Vertucci's classification. (JPMA 68: 423; 2018)

## Introduction

Thorough knowledge of root canal anatomy and its variations is a prerequisite for achieving predictable endodontic outcomes. The success of root canal therapy depends on thorough debridement of the root canal space followed by obturation with an inert material. The inadequate understanding of the canal morphology may result in sub-optimal chemo-mechanical debridement of the canal system leading to poor treatment outcomes.[1]

Maxillary first premolars exhibit single root (22.0 - 49.4%) or two roots (50.6 - 72 %) or even three roots (0-6%).[2-4] These teeth usually have two canals (73.3% - 92%) but are also reported to have a single canal (8-26.2%) or three canals (0-6%).[2-5] Maxillary second premolars usually have a single root but could also present with two or three roots.[6-9] Single canal (60%) is the most common configuration of these teeth followed by two canals (40%) and three canals (0.3%), respectively.[6] Variations in the canal morphology often pose a challenge for clinicians during endodontic treatment. If a clinician is well aware of the typical root canal morphology or its variations, procedural errors can be avoided. There are many factors attributed to these anatomical variations. These include ethnicity,[10] gender,[11] and the study designs employed in the report.[12]

Conventional periapical radiographs are the commonly employed method for evaluating root canal morphology.[13] A periapical radiograph provides a two-dimensional image of a three-dimensional object and hence there is always a chance of missing any important structure present in the third dimension. Sometimes, anatomical limitation, such as shallow vault of the palate or an overlap by the maxillary sinus, pose difficulty in assessing the actual root canal morphology.[14] Cone beam computed tomography (CBCT) provides an accurate three-dimensional image of the entire tooth and is considered to be the best in-vivo method for assessment of the root and canal morphology.[15,16]

Numerous studies have employed CBCT technique to study root canal morphology of maxillary premolars in different populations.[15,16] Pakistan is world's sixth-most-populous country with an estimated population of over 200 million.[17] To the best of our knowledge, no study has reported the root canal morphology of maxillary premolars in this population. Only two local studies were done on maxillary second premolars assessing their number of canals, but not the canal morphology.[18,19] The current study was to evaluate the root and canal

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morphology of maxillary premolars in a sample of Pakistani population using CBCT images and to compare it with the data published in international literature.

## Materials and Methods

This retrospective study was conducted from November 2016 to January 2017 at Aga Khan University Hospital, Karachi, and reviewed CBCT images of maxillary first and second premolars done from November 2014 to October 2016. Approval was obtained from the institutional review committee. All scans were obtained from the hospital's radiographic archives. Sampling technique used was non-probability purposive. Sample size was determined in line with literature.[20] Taking recorded frequencies[20] as anticipated population proportions; absolute precision at 8% and confidence level at 95%, the sample size requirement turned out to be 108 for maxillary first and 109 for maxillary second premolars. We added 5% to compensate for observation errors and hence needed 114 maxillary first and 115 maxillary second premolars. Following inclusion criteria was made: Evaluation of maxillary premolars of males and females of Pakistani origin in the age range of 15-65 years, fully formed roots, no prior endodontic treatment and absence of any root resorption or calcifications. Premolars with apical periodontitis, crown restorations, images with compromised anatomy and poor quality images were excluded.

The CBCT images had been obtained using Sirona Dental system (D-64625 Bensheim, Germany) operated at 85 kVp and 7 mAs. Cross-sectional images had been obtained in the axial, coronal, and sagittal planes and were reconstructed using GALAXIS 1.9 (SICAT GmbH & Co. KG, Bonn, Germany) on a 17-inch personal computer (PC) monitor.

Intra-examiner reliability was assessed on a subset of 20 CBCT images and agreement between two sets of readings was determined using Kappa statistics. Data was analysed using SPSS 19. Mean crown and tooth length, number and configuration of the roots, the number of root canals and the canal configuration (based on Vertucci's classification)[5] was recorded. Chi-square test was applied to determine Vertucci's class with gender. $P \leq 0.05$ was taken as statistically significant.

## Results

Of the 114 maxillary first premolars, 78(68.5%) were bi-rooted and 36(31.5%) were single-rooted. The most common root configuration for the two-rooted maxillary first premolar teeth was flared roots 50(43.9%), followed by fused root 15(13.2%) and fused roots with flaring at the root tip 13(11.4%). Two canaled maxillary first premolars were 102(89.6%), and the rest either had single canal 6(5.2%) or three canals 6(5.2%) (Table-1). The most common canal morphology reported for maxillary first premolars was type I, 127(68%) followed by type II, 24(12.9%) and type III, 14(7.5%) (Table-2). No association was observed between gender and root canal morphology of maxillary first premolars (Table-3). For intra-examiner reliability, the agreement turned out to be excellent at >80%. The mean tooth length of maxillary first premolars was 20.64 ± 1.69 mm and the mean crown height was found to be 6.62 ± 0.67 mm.

The mean tooth length and mean crown length of 115 maxillary second premolars examined were 20.73 ± 1.62 mm and 6.26± 0.59 mm, respectively. Single-rooted maxillary second premolars were 97(84.3%) and bi-rooted were 18(15.7%). The prevalent root configuration reported for bi-rooted second premolars was fused roots with flare at the tip 10(8.7%) or fused roots 8(7%). One and two canaled second premolars were 57(49.6 %) and 56(48.7%), respectively. Only 2(1.7%) second bicuspids

**Table-1:** Frequency distribution of number of the roots and canals in maxillary premolars.

| Number of roots | Maxillary first Premolar n=114 (%) | Maxillary Second Premolar n=115 (%) |
|---|---|---|
| One root | 36 (31.5%) | 97 (84.3%) |
| Two separate roots | 50 (43.9%) | 0 |
| Two fused roots | 15 (13.2%) | 8 (7%) |
| Two apically separated roots | 13 (11.4%) | 10 (8.7%) |
| | | **Number of canals** |
| One canal | 6 (5.2 %) | 57 (49.6%) |
| Two canals | 102 (89.6%) | 56 (48.7%) |
| Three canals | 6 (5.2%) | 2 (1.7 %) |

**Table-2:** Root canal morphology of the maxillary premolars.

| Canal morphology | Maxillary first Premolar teeth = 114 canals = 187 | Maxillary Second Premolar teeth = 115 canals = 133 |
|---|---|---|
| Type I (1) | 127 (68%) | 71 (53.4%) |
| Type II (2-1) | 24 (12.9%) | 18 (13.5%) |
| Type III (1-2-1) | 14 (7.5%) | 8 (6%) |
| Type IV (2) | 0 (0) | 4 (3%) |
| Type V(1-2) | 7 (3.74%) | 6 (4.5%) |
| Type VI (2-1-2) | 6 (3.2%) | 17 (12.8%) |
| Type VIII (3) | 1 (0.5%) | 0 (0) |
| Others | 8 (4.27%) | 9 (6.8%) |
| Total | 187 | 133 |

* Original Vertucci's classification was used.
† Number of canals are reported.

**Table-3:** Distribution of teeth according to the canal morphology of maxillary first premolars in the two genders.

| Canal configuration | Buccal root n=114 | | P- value | Palatal root n=73 | | P- value |
|---|---|---|---|---|---|---|
| | Male | Female | | Male | Female | |
| Type I (1) | 40 | 34 | 0.106 | 29 | 24 | 0.253 |
| Type II (2-1) | 11 | 13 | | | | |
| Type III (1-2-1) | 2 | | | 7 | 5 | |
| Type IV (2) | | | | | | |
| Type V(1-2) | 2 | | | 5 | | |
| Type VI (2-1-2) | 5 | | | 1 | | |
| Type VIII (3) | 1 | | | | | |
| Others | 3 | 3 | | 2 | | |
| Total | 64 | 50 | | 44 | 29 | |

* Original Vertucci's classification (on the basis of individual roots) was used.
† Chi square test was applied at $\leq$ 0.05 level of significance.

**Table-4:** Distribution of teeth according to the canal morphology of maxillary second premolars in the two genders.

| Canal configuration | Buccal root n=115 | | P- value | Palatal root n=18 | | P- value |
|---|---|---|---|---|---|---|
| | Male | Female | | Male | Female | |
| Type I (1) | 35 | 23 | 0.093 | 9 | 4 | 0.480 |
| Type II (2-1) | 9 | 9 | | | | |
| Type III (1-2-1) | 5 | 3 | | | | |
| Type IV (2) | | 4 | | | | |
| Type V(1-2) | 3 | | | 3 | | |
| Type VI (2-1-2) | 7 | 8 | | 2 | | |
| Type VIII (3) | | | | | | |
| Others | 3 | 6 | | | | |
| Total | 62 | 53 | | 14 | 4 | |

* Original Vertucci's classification (on the basis of individual roots) was used.
† Chi square test was applied at $\leq$ 0.05 level of significance.

were three-canaled. Most common canal morphology reported for maxillary second premolars was type I 71(53.4%) followed by type II 18(13.5%) and type VI 17(12.8%). No association was found between root canal morphology of maxillary second premolar with the gender (Table-4).

## Discussion

Various in-vitro and in-vivo methods have been used for studying the root canal morphology.[4,11,20-22] Primary limitation of an in-vitro method is that it requires removal of a tooth. The introduction of CBCT in dentistry has offered a non-invasive, accurate and swift method of evaluation of the root canal morphology. It provides three-dimensional diagnostic images in coronal, axial and sagittal sections, as well as in oblique sections without overlapping of any anatomical structure. Tooth and crown length, number of canals, root and canal morphology can be clearly observed in three-dimensional view. Therefore, CBCT can be considered a precise tool for evaluating tooth morphology.[23] Variations in the root and canal morphology exists among various populations; the present study provides a report on the root morphology and canal configuration of maxillary bicuspids in Pakistani sub-population.

The mean tooth length of maxillary first premolar reported by Pecora et al.[4] was 21mm. Vertucci et al.[5] reported it to be 20.6mm. In our study, it was found to be 20.6±1.69 mm. The mean tooth length reported by Raj et al.[1] for maxillary second premolar was 21.5mm and by Vertucci et al.[24] it was 21.5mm. However, in this study it was found to be 20.73±1.62mm. Our results were comparable to those reported by other investigators but the strength of our study is that we have reported the standard deviations of the mean length and have also reported mean crown height for the two sets of premolars.

We found a myriad of studies reporting the distribution of roots in maxillary premolars.[7,8,16,25-29] In maxillary first premolars, the number of roots reported in various studies were in following range: single root (15.5% - 32%),

two (66% -81%) or three roots (0.8% -9.2%).[7,16,25-29] In the current sample, the proportions of single and bi-rooted were 31.5% and 68.5%, respectively. It was comparable to other studies.[16,27,29] For maxillary second premolars, the distribution of roots reported in various studies are in following range: single root (70% - 92%), two roots (8-30%) and three roots (0.4-0.7%).[7,8,16,29] In our samples, it was found to be single root and two rooted in 84.3% and 15.7%, respectively. Our findings were similar to Turkish and Brazilian population.[16,29] However, none of our premolars had three roots.

Various studies have evaluated the number of canals in the maxillary premolars.[4,9,25,26,30,31] The number of canals in maxillary first premolars are reported in the following range: single canal (2.1- 17.7%), two canals (85-96%) and three canals (1.2- 9.2%).[4,9,25,26,30,31] In our study, the proportion of a single canal in maxillary first premolar was 6(5.2%), two canals and three canals were 102(89.6%) and 6(5.2%), respectively. This is in agreement with the range reported in the published literature.[25,26,30,31] The number of canals in maxillary second premolars reported in the following range: single canal 27-64%, two canals 35-72% and three canals 0.7%.[32,34] In the current study, the proportions of single canal was 49.6%, two canals 48.7% and three canals 1.7%.

The biggest dilemma observed in the canal morphology studies of maxillary premolars canal is the correct application of Vertucci's classification. Most studies had taken whole tooth as a unit for classification. However, the actual Vertucci's classification is based on the individual roots.[7,35,36] A greater number of published studies has considered two rooted premolar as a single root and consequently erroneously reported type IV as the most common type. Adhering to original Vertucci's prescription, we noted that type I is more prevalent within each root. Only Bulut et al.[16] and our study have followed the original Vertucci's classification in that respect.

According to Bulut et al.,[16] for maxillary first premolars, type I (62.6%) canal configuration was most commonly observed among Turkish population followed by type II (34.1%), type IV (1.9 %), type III (0.8%) and type V (0.6%). In Pakistani sample, we also reported that type I (68%) was the most frequent finding followed by type II (12.9%) type III (7.5%), type V (3.74%), type VI (3.2%), type VIII (0.5%) in descending order. Canal configuration other than Vertucci's classification for the first bicuspids was reported to be 4.27% of our sample.

Similarly, for maxillary second premolars too, type I (77.6%) canal configuration was again the most common observation reported by Bulut et al.[16] followed by type II (12.5%), type IV (6.6 %), type V (1.9%), type III (1.3%) and type VI (0.2%). We also observed that Vertucci type I (53.4%) was the most frequent canal configuration followed by type II (13.5%), type VI (12.8%), type III (6%), type V (4.5%), type IV (3%). Canal configurations other than Vertucci's classification for second bicuspids were found to be 6.8% in the present study.

Although, the data presented in the current study is of small sample and that too from a single centre of Karachi. But it's imperative to note that Karachi is the only metropolitan city of the country that houses over 10% of the country's population. All the ethnicities of the country are represented in this city. Moreover, the Aga Khan University Hospital is the largest premier teaching institution of the city which caters to patients from almost all strata of population. Thus, probability of capturing an unbiased representative sample of the Pakistani population is high in our study. Thus, we can extrapolate the results generated from the present study for the Pakistani population.

A study conducted by Celikten et al.[7] concluded that a significant difference ($p < 0.05$) was observed among genders for maxillary first premolars, but the difference was not observed for second premolars ($p > 0.05$). However in our study, no difference between the genders was found for both maxillary first and second premolars ($p > 0.05$).

The limitation of our study was small sample size due to limited number of CBCT scans. Moreover, the data was collected by a single assessor and was conducted in one institution. We recommend that more studies should be carried out on canal configuration of maxillary first and second premolars to help generate data to help dentists perform better endodontics. Lastly, we recommend that investigators working in the area of root morphology and canal configuration should employ Vertucci's classification according to its original prescription i.e. on individual root rather than on whole tooth basis to avoid incorrect reporting of results.

## Conclusions

Most of the maxillary first premolars were two rooted, while maxillary second premolars were single rooted. Majority of maxillary first premolars had two canals while the frequency of single and two canals in the maxillary second premolars were almost equal. The most common canal morphology among Pakistani population was found to be Vertucci's type I in maxillary first and second premolars, respectively. There was no difference among two genders for the root canal morphology maxillary premolars.

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