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ORIGINAL ARTICLE

Examining the root and root trunk's vertical dimensions in extracted permanent maxillary first molar in patients visiting Peshawar Dental Hospital, Peshawar

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ABSTRACT

Objective: To evaluate the root trunk length (RTL) and root length of extracted maxillary permanent first molars (MPFM) and to analyze their variation in relation to age, gender and associated clinical characteristics.

Methods: This cross-sectional study was conducted at Peshawar Dental College and Hospital from March 2021 to February 2022. A total of 135 MPFM with intact roots, cementoenamel junctions, and furcation areas were included, while teeth with anomalies, fractures, resorption, cervical lesions, prior endodontic treatment, or severe dilacerations were excluded. RTL and root length were measured using a digital Vernier caliper (precision 0.01 mm). RTL was recorded from the cervical line to the furcation, and root length from the cervical line to the root apex of the mesiobuccal, distobuccal, and palatal roots. Data were analyzed using SPSS version 21.

Results: Among 135 teeth, 88 (65.2%) were from females and 47 (34.8%) from males. The buccal root trunk (BRT) exhibited the greatest mean length (6.52±2.53 mm), followed by distal and mesial root trunks. The palatal root was the longest (14.31±2.77 mm). Higher mean RTL and RL values were observed in the 41-50 year age group and in males; however, differences across age groups and gender were not statistically significant ($p>0.05$).

Conclusion: MPFM show considerable variation in root trunk and root lengths, with BRT and palatal root demonstrating the greatest mean lengths. Although higher mean values were observed in males and older age groups, these differences were not statistically significant. These morphometric findings may aid periodontal and endodontic treatment planning.

Keywords: Molar (MeSH); Maxilla (MeSH); Tooth Root (MeSH); Root trunk length (Non-MeSH); Root length (Non-MeSH); Maxillary permanent first molar (Non-Mesh);Buccal root trunk (Non-MeSH); Mesial root trunk (Non-MeSH); Distal root trunk (Non-MeSH).

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INTRODUCTION

Root trunk measurements play a critical role in the development, management, and prognosis of periodontal disease due to their close relationship with treatment outcomes. Variations in root trunk length and configuration make molars particularly susceptible to periodontal involvement.[1,2] Maxillary molars usually possess three roots, the mesiobuccal, distobuccal, and palatal roots, although considerable anatomical variation has been documented.[3] Owing to their complex root morphology, including furcation concavities and extensive root surface area, maxillary molars are among the teeth most prone to periodontal disease.[4] Root length and root trunk length are also important considerations for immediate implant placement following molar extraction, where favorable anatomy may contribute to treatment success.[5] Anatomical variations in multirooted teeth increase the likelihood of furcation involvement and periodontal bone loss, thereby complicating periodontal management.[6] Knowledge of root and root trunk anatomy is therefore essential for accurate diagnosis, prognosis, and treatment planning in periodontal therapy.[7] These anatomical characteristics are known to vary with factors such as age, gender, and ethnicity.[8]

Root trunk is defined as the anatomical region extending from the cementoenamel junction to the furcation point.[9] Furcation refers to the area where the root trunk divides into two or more roots and is present only in multirooted teeth. Previous studies have shown that knowledge of buccal, mesial, and distal root trunk lengths of maxillary permanent first molars is essential for accurate diagnosis and assessment of furcation involvement.[10]

Teeth with longer root trunks are generally less susceptible to early periodontal involvement; however, once disease occurs, management becomes more complex.[11] In contrast, periodontal procedures such as root resection or tunneling are more feasible in teeth with shorter root trunks, where adequate bone support is present. In molars with long root trunks and advanced furcation involvement, these procedures are often contraindicated due to limited remaining periodontal support.[12]

In most of Mongoloids roots were shorter but root trunks were longer and properly developed. Taurodontism , a developmental anomaly of teeth which is caused by increased growth of root trunk is also found in most of the Mongoloids.[13] Several international studies have highlighted the significance of root trunk length in determining periodontal disease susceptibility and treatment outcomes in maxillary first molars . A CBCT based study in Mongolia showed that average root length of maxillary first molar was 11.60±1.38 mm.[14]A CBCT-based study from Saudi Arabia reported mean

buccal root trunk lengths of 2.76±0.59 mm for Type A and 3.70±0.59 mm for Type B molars, with corresponding mean root lengths of 11.23±1.53 mm and 11.71±1.53 mm.[1] These findings suggest that shorter root trunks may allow earlier clinical detection of furcation involvement yet offer improved access for periodontal instrumentation and better post-treatment prognosis due to limited periodontal destruction. Similarly, a Serbian study by Kadović J, et al., (2020) reported significantly greater distal root trunk length (7.57±0.86 mm) compared with buccal and mesial aspects, indicating substantial ethnic variation in root trunk morphology. Such variations influence onset of furcation exposure, complexity of debridement, and selection of procedures such as tunneling or root resection.[2]

Population-specific anatomical patterns have been reported in East Asian groups, where shorter roots, longer root trunks, and a higher prevalence of taurodontism are commonly observed.[14,15] These variations influence periodontal bone support, access for instrumentation, and post-extraction implant socket assessment. In Pakistan, limited studies have described variations in multirooted molar anatomy, including root divergence and furcation levels; however, CBCT-based or morphometric data on root trunk length of maxillary first molars remain unavailable, representing a significant gap in the existing literature.[16]

The present study provides the first morphometric dataset based on extracted maxillary permanent first molars from the Peshawar population, thereby addressing this knowledge gap. The generated baseline data offer population-specific reference values that can assist periodontists, endodontists, and oral surgeons in assessing furcation risk, anticipating instrumentation challenges, and making informed decisions regarding tooth preservation versus extraction. Moreover, detailed root and furcation measurements may facilitate implant-socket planning by aiding estimation of residual socket morphology, available bone volume, and appropriate implant dimensions. Collectively, these findings support the development of region-specific, evidence-based clinical protocols, reducing reliance on anatomical data derived from other populations.

METHODS

This cross-sectional study was conducted at Peshawar Dental College and Hospital, Peshawar, Pakistan, over an 11-month period (March 2021 to February 2022). Ethical approval was obtained from the Institutional Research Ethics Board, Prime Foundation (Letter No. Prime/IRB/2021-297 dated March 10, 2021). Extracted maxillary permanent first molars (MPFM) indicated for routine extraction were collected from the Department of Oral and Maxillofacial Surgery after obtaining written informed consent from patients or their attendants.

Teeth with intact and complete roots, preserved cementoenamel junctions (CEJ), and intact furcation areas were included. A total of 135 MPFM were collected, including teeth from 47 males and 88 females aged ≥13 years. The sample size was considered sufficient for descriptive morphometric analysis using Vernier caliper measurements, as direct measurement studies commonly achieve reliable results with comparable numbers of specimens. Teeth extracted for orthodontic reasons, severe carious destruction, advanced periodontal disease with hopeless prognosis, or patient preference for extraction due to socioeconomic constraints to afford endodontic procedures were eligible. Teeth with root anomalies, fractures, resorption, cervical or non-carious cervical lesions, previous endodontic treatment, or severe root dilacerations were excluded.

All teeth were cleaned of blood, debris, calculus, and soft tissue using detergent, scalpel blades, and ultrasonic scaling. Each specimen was stored individually in 3% hydrogen peroxide for 24 hours, properly labeled, washed with water, and later preserved in 10% formalin throughout the study period. Each tooth was thoroughly washed with water before measurements were taken. The lengths of the root trunk (Figure 1) and the root (Figure 2) were measured on each extracted permanent maxillary first molar using a digital Vernier caliper with a precision of 0.01 mm. Root trunk length (RTL) and root length (RL) were measured using a digital Vernier caliper with 0.01-mm precision.

RTL (Figure 1) was defined as the vertical distance from the deepest point on the cervical line to the furcation level and was measured on the buccal, mesial, and distal aspects. Root length (Figure 2) was measured from the cervical line to the root apex for the mesiobuccally, distobuccal, and palatal roots. All measurements were recorded on a pre-structured data sheet. After completion of measurements, specimens were disposed of

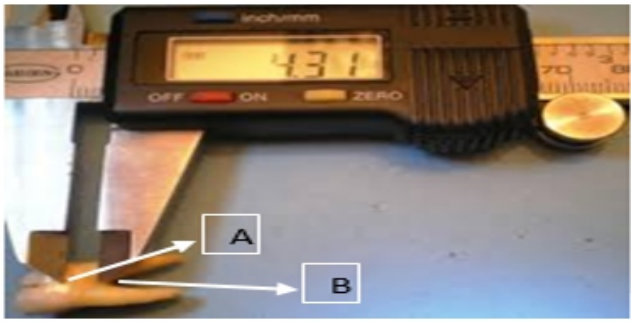

Figure 1: Root trunk length: distance from deepest point A on cervical line to bifurcation/trifurcation point B

Figure 2: Root length: distance from CEJ to root apex

as regulated medical waste following institutional protocols.

Data were analyzed using SPSS version 21. Descriptive statistics including frequencies, percentages, means, and standard deviations were calculated for age, RTL, and RL. Comparisons of mean RTL and RL by gender were performed using Student's t-test. A p-value <0.05 was considered statistically significant.

RESULTS

Root trunk length (RTL) and root length (RL): Table I displays the mean values of root length and root trunk length for maxillary permanent first molars (MPFM). According to the current study, the MRT and DRT had respective lengths of 5.47±2.59 mm and 5.80±2.56 mm, while the BRT measured 6.52±2.53 mm. It shows that BRT has the longest root trunk length followed by DRT and MRT, respectively.

Our study shows that PR is longest having mean length of 14.3±2.77mm whereas the DBR and MBR has almost same mean lengths i.e. 12.88±2.86mm and 12.76±2.95 mm.

Distribution of participants according to gender and age groups: A total of 135 participants were included in the study, of whom 88 (65.2%) were females and 47 (34.8%) were males. Most participants were aged between 21-30 years (25.9%), followed by 31-40 years (23.7%), Table II.

Comparison of length of root trunk and root of MPFM with gender and age: The comparison of root length and root trunk length with age and gender was done. The highest mean root trunk length and root length were observed in the 41-50 year age group, while the lowest mean values were seen in individuals younger than 20 years. However, no statistically significant difference in root trunk length or root length was observed across the different age groups (p>0.05) as shown in Table III.

The mean root trunk length was 6.16±2.46 mm in males and 5.69±2.47 mm in females (p=0.504), while mean root length was 14.05±2.73 mm and 12.90±2.65 mm, respectively (p=0.496). Although males showed higher mean root trunk length and root length than females, the differences were not statistically significant (p>0.05)." as shown in Table IV.

Table I: Descriptive statistics of root trunk and root lengths of permanent maxillary first molars

Variable	Minimum length	Maximam length	Mean±SD
BRTL	1.86mm	13.37mm	6.52±2.53 mm
MRTL	2.57mm	10.32mm	5.47±2.59 mm
DRTL	1.5mm	11.88mm	12.76±2.957mm
MBRL	7.47mm	20.06mm	12.88±2.86mm
DBRL	9.29mm	19.57mm	12.76±2.957mm
PRL	9.52mm	20.64mm	14.31±2.77mm

BRTL (Buccal Root Trunk Length), MRTL (Mesial Root Trunk Length), DRTL (Distal Root Trunk Length), MBRL (Mesiobuccal Root Length), DBRL (Distobuccal Root Length), PRL (Palatal Root Length)

Table II: Distribution of participants by gender and age group

Variable	Category	Frequency (n=135)	Percentage (%)
Gender	Female	88	65.2
	Male	47	34.8
Age groups (years)	<20	22	16.3
	21-30	35	25.9
	31-40	32	23.7
	41-50	24	17.8
	>50	22	16.3

Table III: Comparison of root trunk length and root length according to age group (n=135)

Age Groups (years)	Frequency (%)	Root Trunk Length (mm) Mean±SD	Root Length (mm) Mean±SD	p-value
<20	22(16.3)	4.986±1.785	12.20±2.630	0.082
21-30	35 (25.9)	5.905±2.550	13.143±2.522	0.949
31-40	32 (23.7)	6.155±2.699	13.458±2.876	0.725
41-50	24 (17.8)	6.747±2.556	14.172±2.791	0.676
>50	22 (16.3)	5.445±2.445	13.602±2.722	0.627

The correlation between root trunk length and root length with age was not statistically significant (p<0.05)

Table IV: Comparison of root trunk length and root length according to age group (n=135)

Gender	Frequency (%)	Root Trunk Length (mm) Mean±SD	Root Length (mm) Mean±SD	p-value
Female	88 (65.2%)	5.686±2.469	12.899±2.653	0.504
Male	47 (34.8%)	6.163±2.464	14.046±2.726	0.496

DISCUSSION

The present study evaluated the morphology of extracted permanent maxillary first molars by analyzing root

trunk types, root trunk lengths, and root lengths. Among the root trunk dimensions, the buccal root trunk demonstrated the greatest mean length, while the palatal root was the longest among all roots. Importantly, no statistically significant association was identified between these morphometric parameters and patient age or gender. These findings provide important morphometric baseline data that may aid clinicians in periodontal risk assessment and treatment planning.

In the present study, the buccal root trunk length exhibited the highest mean value (6.52±2.53 mm), followed by the distal (5.80±2.56 mm) and mesial (5.47±2.59 mm) root trunks. These findings differ from those reported by Kadović J, et al., in a Serbian population, where the distal root trunk length was significantly greater than both the mesial and buccal root trunks.[2] Similarly, Mabrouk R, et al., reported contrasting results in a Tunisian population, demonstrating the mesial root trunk as the longest and the buccal root trunk as the shortest among maxillary first molars.[18] In another study, DababnehR, et al., observed that the buccal root trunk was shorter than both the mesial and distal root trunks, further differing from the findings of the current study.[19] These variations in root trunk morphology across studies may be attributed to ethnic diversity, genetic influences, and geographical differences among populations.

When compared with previously published studies, the findings of the present study demonstrate both concordance and divergence. In agreement with the observations of Dababneh R, et al., the buccal and distal aspects predominantly exhibited type B root trunks; however, in contrast to their findings, the mesial aspect in the current study showed a higher prevalence of type A root trunks.[19] Variations from studies conducted in Saudi Arabian, Serbian, and Tunisian populations further suggest that root trunk morphology is influenced by population-specific and geographic factors.[2,18]

Regarding root length, the palatal root was the longest (14.31±2.77 mm), followed by the mesiobuccal (12.88±2.86 mm) and distobuccal (12.76±2.95 mm) roots. These findings are consistent with those reported by Kadović J, et al., Mabrouk R, et al., and Dababneh R, et al., all of whom documented similar length patterns among the three roots of maxillary first molars.[2,18,19]

According to the findings of the present study, male subjects demonstrated slightly greater root and root trunk lengths than female subjects in permanent maxillary first molars. These observations are comparable to findings reported in studies conducted in the Tamil population, particularly with respect to root length measurements.[20,21] The modest gender-related differences observed in the current study are consistent with existing literature suggesting that dental root dimensions may contribute to sex determination in forensic odontological assessments.

In the present study, the assessment was limited to the measurement of root trunk length and root length of MPFM. In contrast, several previous studies have also evaluated interradicular space width, an important parameter influencing root preparation and periodontal instrumentation. These studies reported that, in maxillary first and second molars, the buccal interradicular space is the narrowest, with a mean width of 1.18±0.39 mm.[18,25] Furthermore, Goh EX, et al., highlighted additional anatomical variables-including root concavities, furcation entrance diameter, cervical enamel projections, root trunk length, and molar root fusion-in their review, emphasizing the clinical relevance of these factors in the diagnosis and management of periodontal disease.[12,22,26]

Understanding root trunk morphology is of critical importance in both periodontal and endodontic therapy. Teeth with shorter root trunks tend to exhibit earlier furcation exposure during periodontal disease progression, rendering them more susceptible to furcation involvement. Conversely, teeth with longer root trunks are relatively less prone to early periodontal involvement; however, from a therapeutic perspective, teeth with shorter root trunks often have a more favorable prognosis, as furcation areas become more accessible for visualization, instrumentation, and effective periodontal management.[2,27]

These observations highlight that although certain anatomical patterns of maxillary permanent first molars appear consistent across various populations; significant regional variations persist. By providing population-specific baseline data from Peshawar, the present study aids clinicians in anticipating anatomical challenges and making informed decisions during periodontal and endodontic treatment planning.

CONCLUSION

The buccal root trunk demonstrated the greatest mean length among the root trunks of maxillary permanent first molars, followed by the distal and mesial root trunks, while the palatal root was the longest, followed by the mesiobuccal and distobuccal roots. Male subjects generally exhibited longer root and root trunk lengths than female subjects, whereas no statistically significant association was observed between age and either root trunk or root length. The present study provides important morphometric baseline data highlighting clinically relevant anatomical variations in maxillary permanent first molars, which may assist clinicians in anticipating furcation involvement, optimizing periodontal and endodontic treatment planning, and refining implant-related decision-making. Incorporation of this anatomical knowledge into clinical practice may help reduce procedural complications and improve long-term outcomes for both natural teeth and dental implants.

Future Recommendations

1. Future studies should include larger and more diverse populations to validate the present findings and to explore potential regional and ethnic variations in the morphology of maxillary permanent first molars.

2. The use of high-resolution imaging modalities, such as cone-beam computed tomography (CBCT) or micro-computed tomography (micro-CT), is recommended to obtain more accurate measurements and to better elucidate the three-dimensional anatomy of root and root trunk structures.

3. Further research should investigate the clinical implications of variations in root and root trunk morphology with respect to periodontal therapy, endodontic procedures, and tooth extraction outcomes.

4. Additional studies are warranted to examine the relationship between root and root trunk dimensions and other anatomical characteristics, including root canal configuration, furcation anatomy, and crown morphology.

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AUTHORS' CONTRIBUTION

The Following authors have made substantial contributions to the manuscript as under:

BK: Acquisition, analysis and interpretation of data, drafting the manuscript, approval of the final version to be published

MAK: Conception and study design, critical review, approval of the final version to be published

SA & IK: Acquisition, analysis and interpretation of data, drafting the manuscript, critical review, approval of the final version to be published

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICT OF INTEREST

Authors declared no conflict of interest, whether financial or otherwise, that could influence the integrity, objectivity, or validity of their research work.

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DATA SHARING STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request

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