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Assessment of Maxillary Premolar Root Position Within the Alveolar Bone Using Cone Beam Computed Tomography

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ABSTRACT

The location of maxillary premolars with respect to the alveolar bone and maxillary sinus is critical for treatments like extractions and implantation. CBCT imaging provides extensive information on root placement, sinus proximity, and buccal bone dimensions, enabling proper diagnosis and treatment planning. **Objectives:** To assess the position of the maxillary premolars' roots within the alveolar apparatus and their relationship to the maxillary sinus using cone-beam computed tomography. **Methods:** This is a cross-sectional descriptive study that included CBCT images of 105 patients with 411 maxillary premolars were viewed retrospectively over a period of six months. After obtaining permission from the institutional ethical review committee, each pair of premolars was observed on either side of the mouth. Each exhibited a distinct association between its root tip and the sinus floor, categorized into four different types. The roots were also variable in the alveolar housing and were either buccal, middle, or palatally placed with varying dimensions of buccal bone. **Results:** In our study, the majority of maxillary first premolars had roots positioned away from the sinus floor, with root angulation predominantly directed toward the buccal side. In contrast, most second premolars exhibited roots located close to or extending into the sinus floor, with their roots generally positioned centrally within the alveolar bone. **Conclusions:** Maxillary first premolars are mostly buccally placed with thinner associated buccal bone, whereas second premolars are more affected by sinus proximity during implant insertion operations. Given these specific anatomical obstacles, CBCT imaging is recommended for accurate diagnosis and effective implant design.

INTRODUCTION

Knowledge of the root position of any tooth within the alveolar housing is an important diagnostic parameter before instituting any treatment in the oral cavity [1]. The maxillary premolars, in particular, pose a clinical challenge during surgical procedures owing to their complex and variable root anatomy [2]. They also serve as transitional teeth as we go from anterior incisors to maxillary molars and, therefore, are often in close relation to the sinus in the maxilla [3]. The apposition of maxillary premolars to the floor of the maxillary sinus must be carefully assessed before performing any surgical procedures involving these teeth. Roots that are protruding or close to the maxillary sinus may increase the risk of perforation of the sinus membrane or facilitate the entry of foreign material into the cavity of the sinus. Implant placement in such situations requires maxillary sinus augmentation through a crestal approach or open surgery [4, 5]. Another important factor while placing dental implants is the buccal bone thickness, which is detrimental to both implant stability and esthetic outcome [6]. Chronic tooth loss results in

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alveolar bone resorption, where the buccal aspect demonstrates a more prominent presentation than the palatal [1, 6]. The subsequent thin buccal plate is more prone to fracture and results in fenestration or dehiscence-type defects that often require bone augmentation [7]. Buccal bone thickness is also important while instituting endodontic therapy, as a thin buccal bone at the apex can facilitate sinus tract formation [1]. Therefore, it is equally essential to determine how these teeth are positioned within the alveolar bone. For pre-surgical assessment of implant sites in the oral cavity, cone-beam computed tomography proves extremely beneficial [8]. While numerous studies have been conducted to evaluate the root position of maxillary posterior teeth relative to the maxillary sinus floor, limited data are available to precisely describe this relation in a specific ethnic population [9]. Although the anatomical relationships of premolars to the alveolar bone and maxillary sinus are well-documented in the literature, data specific to South Asian populations remain limited. This study addresses this gap and contributes population-specific insights.

This study aimed to investigate how maxillary premolars relate to the sinus floor, their spatial location within the alveolus, and the subsequent proportions of the buccal bone in a selected Pakistani demographic.

METHODS

This cross-sectional descriptive study was conducted in the Department of Periodontology and Implantology at Lahore Medical and Dental College, Lahore, over six months (March–August 2024), after approval from the institutional review committee (Ref. No. LMDC: FD/5102/24). A total of 107 patients who had undergone CBCT examination for various reasons during the past five years (2020–2024) were included using the convenience non-probability sampling technique, and sample size was calculated using the WHO sample calculator formula with a 95% confidence interval, expected prevalence of 50% (p = 0.5), and precision of ±10% (d = 0.10). The final cohort consisted of 105 patients with a total of 411 premolars, and each participant had given consent for the use of their data for academic purposes. Inclusion criteria were patients aged 20–70 years who had undergone CBCT examination and had at least one premolar, while exclusion criteria included severe alveolar bone loss secondary to periodontal disease, periapical and sinus pathologies, history of orthodontic therapy, compromised image quality, artifacts, or prior surgical procedures. CBCT scans were performed using the Dentsply Sirona Galileo Comfort Plus machine at 90 kV, 12 mA, 16 seconds, with a voxel size of 150 µm and a field of view of 11 cm × 10 cm, and the obtained 2D images were processed into 3D models in Galileo software and viewed using Galaxis Galileos viewer. Each CBCT image was evaluated in a cross-sectional view to assess both maxillary premolars, their relationship with the maxillary sinus, root location in the alveolus, and buccal bone thickness. A single trained examiner recorded the sinus relationship according to Jung YH et al.'s classification [1] categorized as Type 0: root separate from sinus floor; Type 1: close contact between root and sinus floor; Type 2: sinus floor lying below the root apex without protrusion; and Type 3: root apex extending into the maxillary sinus cavity (Figure 1).

Figure 1: Classification of root–sinus relationship

The root position within the alveolar housing was also categorized according to Jung YH et al. [1], with Type A: buccal (root tip in the buccal third), Type B: middle (root tip centrally positioned), and Type C: palatal (root tip in the palatal third of the alveolar bone)(Figure 2).

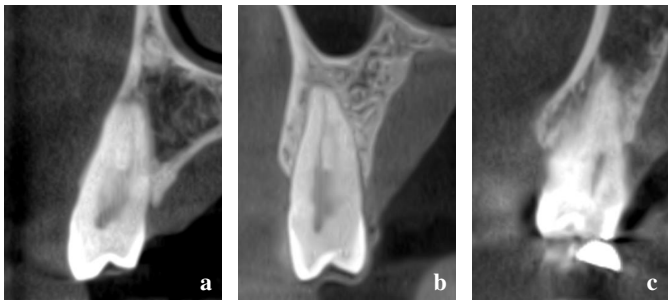

Figure 2: Classification of Root Position of Premolars in the Alveolar Bone

Buccal bone thickness was measured at two points, 1 mm below the alveolar crest and at the root apex, with a value of 0.00 assigned in cases of dehiscence/fenestration or bone thickness <0.1 mm (Figure 3).

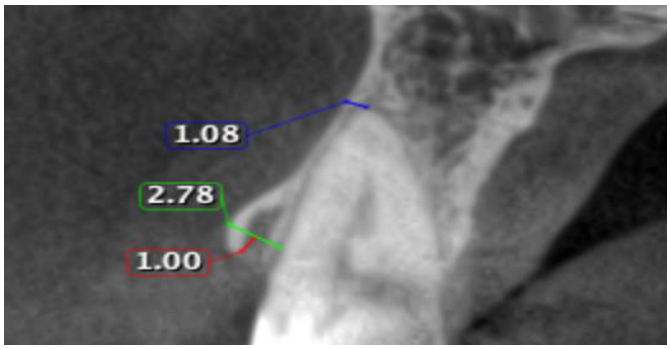

Figure 3: Measurements Taken at the Bone Crest (1mm Below) and at the Root Apex

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A second trained examiner cross-checked all measurements, and discrepancies resulted in exclusion; thus, two patients were excluded, leaving 105 for analysis. Inter-examiner reliability was assessed on 20 cases, with an ICC of 0.89 for continuous data (good agreement) and Cohen's Kappa of 0.76 for categorical data (substantial agreement). The data were examined with SPSS version 22, which used descriptive statistics to categorize findings by age and gender. Correlation, Chi-square, and Games-Howell post-hoc tests were used, with p-values less than 0.05 indicating statistical significance.

RESULTS

In the present study, both CBCT imaging and the spatial relationship between maxillary premolars and maxillary sinus were used to assess the spatial relationship in this study. A total of 411 premolars were analyzed, had 206 first premolars and 205 second premolars (Table 1).

Table 1: Classification of Maxillary Premolars Based on Root–Sinus Relationship

Relationship with the sinus	First Premolar	Second Premolar
Type 0	171 (81.4%)	64 (30.5%)
Type 1	33 (15.7%)	93 (44.3%)
Type 2	2 (1%)	14 (6.7%)
Type 3	0 (0)	34 (16.2%)
Total	206	205

Most first premolars (Type A, 85%) were buccal in terms of their root position within the alveolar bone, whereas second premolars were most frequently centrally positioned (Type B, 50.5%). Palatal position (Type C) was rare in both premolar groups (Table 2).

Table 2: Localization of Maxillary Premolar Roots in the Alveolar Bone

Root Position	First Premolar	Second Premolar
A (Buccal)	179 (85%)	94 (44.8%)
B (Central)	22 (10.5%)	106 (50.5%)
C (Palatal)	5 (2.4%)	5 (2.4%)
Total	206	205

There were no statistically significant differences in first premolars when examining the relationship between root position and sinus relationship ($P > 0.05$). However, in second premolars, a significant association was observed ($P < 0.05$): Type 0 was mainly buccal (A), while Types 1, 2, and 3 were predominantly central (B) (Table 3).

Table 3: Association Between Root Positions of Maxillary Premolars and Their Sinus Relationship

Category	A	B	C	Total	p-Value
First Premolar					
Type 0	151 (88.3%)	16 (9.4%)	4 (2.3%)	171	0.1832
Type 1	26 (78.8%)	6 (18.2%)	1 (3.0%)	33	
Type 2	2 (100%)	0 (0%)	0 (0%)	2	
Type 3	–	–	–	–	
Subtotal	179 (86.9%)	22 (10.5%)	5 (2.4%)	206	
Second Premolar					
Type 0	41 (64.1%)	19 (29.7%)	4 (6.2%)	64	0.0018
Type 1	36 (38.7%)	56 (60.2%)	1 (1.1%)	93	
Type 2	3 (21.4%)	11 (78.6%)	0 (0%)	14	
Type 3	14 (41.2%)	20 (58.8%)	0 (0%)	34	
Subtotal	94 (44.8%)	106 (50.5%)	5 (2.4%)	205	

In terms of buccal bone thickness, first premolars consistently showed thinner bone than second premolars, particularly at the crest and apex. Buccally positioned roots (Type A) exhibited the thinnest dimensions compared with centrally or palatally placed roots (Table 4).

Table 4: Relationship Between Root Position and Buccal Bone Thickness in Maxillary Premolars

Root Position	First Premolar (1 mm below crest)	Second Premolar (1 mm below crest)	First Premolar (apex)	Second Premolar (apex)
A	0.74 ± 0.51	0.99 ± 0.66	0.64 ± 0.64	1.01 ± 0.67
B	1.76 ± 0.89	1.91 ± 0.91	2.30 ± 1.12	2.31 ± 1.10
C	2.30 ± 1.29	2.16 ± 1.07	1.42 ± 1.32	4.28 ± 2.55

When stratified by sinus relationship, premolars with Type 0 connection exhibited the thinnest buccal bone at the root apex. At the alveolar crest, most first premolars had <1 mm bone thickness, while second premolars exceeded 1 mm. The difference in buccal bone thickness at the apex between first and second premolars was statistically significant ($P<0.05$) (Table 5).

Table 5: Buccal Bone Thickness of Maxillary Premolars Based on Sinus Relationship

Relation with sinus	First Premolar (1 mm below crest)	Second Premolar (1 mm below crest)	p-Value	First Premolar (apex)	Second Premolar (apex)	p-Value
Type 0	0.88 ± 0.71	1.46 ± 0.99	0.0653	0.84 ± 0.89	1.85 ± 1.59	0.037
Type 1	0.88 ± 0.69	1.58 ± 0.88		0.79 ± 0.84	1.80 ± 1.03	
Type 2	1.18 ± 0.01	2.09 ± 1.12		1.84 ± 0.35	1.93 ± 1.11	
Type 3	–	1.33 ± 0.77		–	1.44 ± 1.03	

DISCUSSIONS

Gaining insight into the spatial relationship between the sinus and premolar roots is essential for clinicians, as it plays a critical role in the successful planning and execution of periapical surgeries, implant placements, and surgical endodontic treatments involving these teeth. Accurate knowledge of this anatomy helps minimize surgical risks and improve treatment outcomes [10]. The relationship between the maxillary posterior teeth and the maxillary sinus has been studied in several previous research works [11, 12]. However, little research has explored this relation in the maxillary premolars [1]. This study focused on studying these parameters in a specific

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ethnic population. In our study, most maxillary first premolars (81.4%) were Type 0, positioned away from the maxillary sinus, and none presented with a Type 3 relationship (protruding into the sinus). This finding coincides with previously reported data [13]. Moreover, in this study, the second premolars were mostly (44.3%) Type 1 with roots in contact with the sinus. A considerable amount of second premolar roots (16.2%) was also found to be Type 3 (protruding into the sinus), consistent with other CBCT-based studies [14]. The sagittal root position of teeth involved is an important factor to be addressed when planning and locating the dental implants in the maxillary premolar area [2]. This anatomical aspect is important in the realization of the ideal implant position and prevention of the complications caused by the involvement of cortical bone or sinuosity. In the current study, the proportion of first premolars that assumed a buccal position (which is Type A in the sagittal classification) was shown to be significant (around 85 percent). The second premolars, conversely, were most often found centrally in the alveolar housing, thus being Type B. These are in line with the data that have been published before [15]. Interestingly, Type C positioning, in which the apex of the root is placed nearer to the palatal cortical plate, was relatively fewer in the first and the second premolars. In our analysis, this arrangement was noted in very few, 2.4% of the analyzed premolars, which is not very common as compared to Types A and B. Lastly, the buccal bone thickness is another important factor to be considered during implant placement [8]. The alveolar bone undergoes significant remodeling after tooth extraction, and the resulting dimensional change is determined by the pre-extraction buccal bone thickness [16]. Teeth with a buccal bone thickness of less than 1 mm are more prone to vertical ridge resorption, posing a challenge to implant placement [17]. Several authors have studied this dimension in their previous studies [18-20]. We also examined buccal bone thickness at two levels: 1 mm below the alveolar crest and at the root apex. In the maxillary premolars, the first premolars demonstrated a thinner buccal plate compared with the second premolars, a finding consistent with previous work [21]. This difference reached statistical significance at the 1 mm subcrestal level ($p<0.05$), indicating a higher risk area for implant placement due to limited cortical support. At the apical level, bone dimensions are comparable in deeper regions between the two sites, with no statistically significant difference.

CONCLUSIONS

Maxillary premolars differ in position and bone structure: first premolars have thinner buccal bone and are more prone to post-extraction resorption, while second premolars more often protrude into the sinus. Careful CBCT assessment is recommended for treatment planning, with consideration given to bone grafting and a two-stage implant approach when necessary.

Authors Contribution

Conceptualization: MUK
Methodology: MM, AD
Formal analysis: AD, UM, NK
Writing review and editing: MM, UM, NAA, NK, MUK

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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