Original Research Article

Evaluation of sagittal root position of maxillary anterior teeth: A cross-sectional CBCT study

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Abstract

Introduction: Precise implant placement in the maxillary anterior region is critical for esthetics and function. Sagittal Root Position (SRP), referring to the natural tooth's position within the alveolar bone, significantly impacts post-extraction site morphology, implant stability, and bone integrity. This study evaluated SRP prevalence in the Indian population to provide essential baseline data for implant treatment planning.

Methods: We analyzed 100 CBCT scans of the anterior maxilla, assessing all six anterior teeth. SRP was classified using a established system: Class 1 (root against labial cortical plate), Class 2 (root centered), Class 3 (root against palatal cortical plate), and Class 4 (root engaging both cortical plates). Frequency and bilateral symmetry were analyzed, along with gender comparisons.

Results: A favorable Class I position was found in 46.6% of teeth. The unfavorable Class III position was rare, at just 0.33%. Bilateral symmetry was high, especially for canines (80%) and lateral incisors (76%). SRP showed no significant gender differences, except for specific lateral incisors and canines.

Conclusion: The high prevalence of Class I SRP in the Indian population suggests generally favorable conditions for immediate implant placement in the maxillary anterior region. Identifying SRP through CBCT is crucial for effective pre-surgical planning, enabling clinicians to predict implant stability and mitigate risks, ultimately optimizing implant success and esthetics.

Keywords: Sagittal root position, Maxillary anterior, Dental implants, CBCT.

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1. Introduction

Dental implants are the most reliable restorative option for replacing missing teeth and are poised for explosive growth in the coming decade. Despite being the nearest equivalent replacement of natural tooth, they have not always enjoyed a favourable reputation owing to the inadvertent association of most surgical and prosthetic combination, which can be avoided with proper pre-surgical planning.

Implant placement in maxillary anterior region is the most important as also the most challenging, attention must be paid to implant positioning to ensure good esthetics, functional stability and phonetics. When implants are placed too buccally, dehiscence occurs in the buccal cortical plate which increases the likelihood of gingival recession. If placed more palatal, a ridge-lap prosthesis may be preferred to accommodate excessive buccal contours.[1-3] Thickness of buccal wall when maintained to atleast 1mm prevents gingival recession and improvises aesthetics. Spray et al has reported in their case study that when the thickness of bone approached 1.8-2mm, bone loss gradually decreased.[4] In addition, also important is that the implant should be

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positioned in such a way that it mimics natural tooth position. In order to achieve this, implant center should be positioned to match the center of the tooth to be replaced.[5]

A minimum distance of 1.5-2mm is mandatory between implants and adjacent teeth. When placing multiple implants in edentulous area a gap of 3-4mm is highly recommended, If not followed, it leads to forfeit of inter-proximal bone and papilla.[6,7]

Implants placed should have an abutment that provides the prosthesis a natural tooth like appearance. Anterior aesthetic zone is an area where improper angulation can cause compromised aesthetics especially in high and medium smile lines.[6] Incorrect angulation during surgery can lead to perforation of facial or palatal bone wall.

Long term stability of soft tissue depends largely on buccal bone and gingival biotype, of which the later cannot be changed, therefore, 3-dimmensional imaging is importunate to judge the adequacy of buccal bone thickness over the implant surface.

Wang et al and Lau et al, have suggested that the implant axis should be placed in a way that it mimics the natural tooth root and is parallel to tooth root axis. Root position has been found to be crucial in implant treatment planning concerning the anterior aesthetic zone particularly in immediate implant therapy.[8,9] The original root position in the alveolar bone was found to explain the morphology of post extraction site, further influencing the implant stability and bone perforation.[10] Kan et al, concluded that clinical relevance of sagittal root position will provide adjunct data for treatment planning of immediate implant placement and previsualization of anterior maxilla.[11]

Taking into consideration all the above points important for the success of implants, we designed a study to assess the influence of SRP in maxillary anterior region.

Studies have been done in different ethinic groups, however to our knowledge no such studies are done for Indian population. Hence, this study was planned with the aim to provide baseline data for the Indian population.

2. Aim and Objectives

Evaluation of sagittal root positions in maxillary anterior aesthetic zone.

1. Comparison of Root inclination of anterior teeth across the genders.
2. Comparison between root inclination of anterior teeth on right and left side.

3. Materials and Methods

Study was conducted at Department of Oral Medicine and Radiology, D. Y. Patil University School of Dentistry, Nerul, Navi Mumbai.

The study was performed on CBCT scans of the anterior maxilla to evaluate all the six anterior teeth and was approved by the institutional ethical committee.

A total of 100 CBCT scans were obtained randomly from the secondary database with details on age and gender noted.

3.1 Inclusion criteria

Good quality CBCT images showing six healthy maxillary anterior teeth with their surrounding alveolar bone.

Scans of subjects above 21 years of age.

3.2. Exclusion criteria

1. Any teeth with periodontal or periapical lesion, restorations, presence of Supernumerary teeth.
2. Any bone abnormalities due to systemic diseases.
3. No radiographic evidence of infection, severe root resorption and/or trauma to anterior maxillary dentition.
4. No radiographic evidence of surgical (guided bone / tissue regeneration) treatment in anterior maxillary dentition.

3.3. CBCT scanning

The included CBCT scans were made using CS 9000 3D unit (Carestream Health) **Figure 1**. (Version 2,12,10,10 copyright carestream Healthinc., 150 Versonal street, Rochester, NY 14608, USA) FOV for single volume being: 5 cm X 3.75 stitched volumes (up to 3) : 9 cm X 7.5cm X 3.5cm.

All scans were taken according to the manufacturer's recommended parameters. The subject's head position for each scan was oriented with axial plane set parallel to the floor. The sagittal plane set perpendicular to the floor and the coronal plane perpendicular to both the axial and sagittal planes.

CBCT data sets were saved in Digital Imaging and Communications in Medicine (DICOM) format. The CBCT images were analysed using an imaging software (CS 3D; Carestream Healthinc., 2011) and a HP Windows Desktop (Compaq LE 1911); 21 Inch with a resolution of 1440 X 900 pixels. The contrast function was regulated and magnifying device was activated when required.

The X and Y cursors were used for horizontal and vertical orientation of CBCT images of the bone. In order to survey the morphology of the bone width and bone height from the axial plane, the Z cursor was moved slowly in cervico-apex direction.

Data was reconstructed by using cross sectional slices in the paraxial plane, perpendicular to the alveolar ridge at 2µm intervals. Landmarks were identified and arch form was drawn by joining mid-points of pulp chamber of the teeth. (**Figure 1**).

Figure 1: Reconstruction of curved slicing for measurements
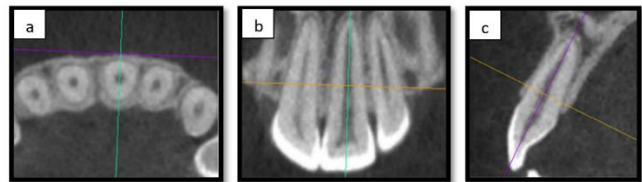

Figure 2: Orientation of scans for measurements of SRP

In the same sagittal section, passing through midway through the tooth, SRP of teeth were categorized according to Kan et al **Figure 3** as,
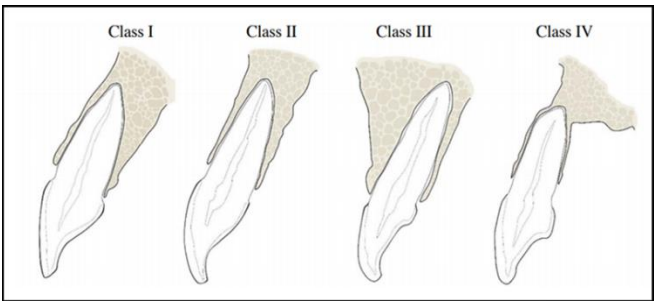

Figure 3: Schematic classification from Kan et al.[11]

Class 1: Root is positioned against the labial cortical plate
Class 2: Root is centered in the middle of the alveolar housing, without engaging the labial or lingual cortical plate in the apical third.
Class 3: Root is positioned against the palatal cortical plate
Class 4: Atleast 2/3rd of the root is engaging both the buccal and lingual cortical plate.
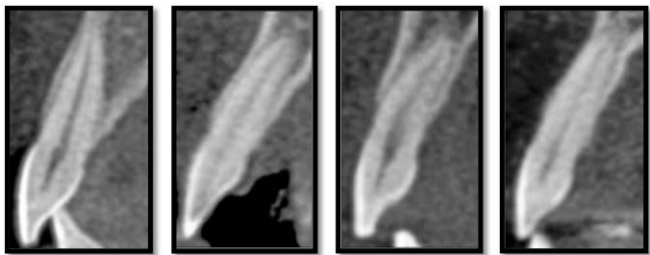SRP was noted for all the six anterior teeth.

Figure 4: Images showing Class I, Class II, Class III, Class IV

3.4. Statistical analysis

Frequency analysis was done for SRP in different types of teeth, and for checking on bilateral symmetry.

4. Observations and Results

Frequency **Table 1** shows that only 2 CIs of the 600 evaluated teeth had Class III Root position. Most of the teeth were found to be placed in Class I position across all the 3 types (CI, LI, CN). Both right and left CI were found to have a near equal prevalence of Class 1 and Class 2 root position. While laterals were found majorly in class I position followed by near equal prevalence of Class II and Class IV. CNs were found in class I position in over 50% of sample on both right and left side.

Table 1: Root inclination in different classes of teeth

		Count	**Column N %**
SRP: CI 1	Class I	42	42.0%
	Class II	46	46.0%
	Class III	2	2.0%
	Class IV	10	10.0%
SRP: CI 2	Class I	40	40.0%
	Class II	48	48.0%
	Class III	**0**	0.0%
	Class IV	12	12.0%
SRP: LI 1	Class I	44	44.0%
	Class II	34	34.0%
	Class III	**0**	0.0%
	Class IV	22	22.0%
SRP: LI 2	Class I	42	42.0%
	Class II	28	28.0%
	Class III	**0**	0.0%
	Class IV	30	30.0%
SRP: CN 1	Class I	56	56.0%
	Class II	32	32.0%
	Class III	**0**	0.0%
	Class IV	12	12.0%
SRP: CN 2	Class I	56	56.0%
	Class II	28	28.0%
	Class III	**0**	0.0%
	Class IV	16	16.0%

Table 2: Bilateral comparison

SRP: CI					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Similar	64	64.0	64.0	64.0
	Dissimilar	36	36.0	36.0	100.0
	Total	100	100.0	100.0	
SRP: LI					
	Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**	
Valid	Similar	76	76.0	76.0	76.0
	Dissimilar	24	24.0	24.0	100.0
	Total	100	100.0	100.0	
SRP: CN					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Similar	80	80.0	80.0	80.0
	Dissimilar	20	20.0	20.0	100.0
	Total	100	100.0	100.0	

Comparison between the left and the right teeth showed, 64% of the CIs were found to be similar to the opposite side. Highest similarity was found between the CNs, wherein 80% CNs were found to have the same SRP as their counterpart. (**Table 2**)

Table 3: Sagittal root position and gender

Count		**Male**	**Female**	**Total**	**p-value**
SRP CI -1	Class I	22	20	42	0.145
	Class II	16	30	46	
	Class III	0	2	2	
	Class IV	6	4	10	
SRP CI - 2	Class I	20	20	40	0.537
	Class II	20	28	48	
	Class III	0	0	0	
	Class IV	4	8	12	
SRP LI -1	Class I	22	22	44	0.195
	Class II	16	18	34	
	Class III	0	0	0	
	Class IV	6	16	22	
SRP LI -2	Class I	26	16	42	0.002
	Class II	12	16	28	
	Class III	0	0	0	
	Class IV	06	24	30	
SRP CN-1	Class I	32	24	56	0.001
	Class II	12	20	32	
	Class III	0	0	0	
	Class IV	0	12	12	0.74
SRP CN-2	Class I	30	26	56	
	Class II	10	18	28	
	Class III	0	0	0	
	Class IV	4	12	16	

P-value was not significant for most of the groups when compared between males and females. Equal prevalence was found for SRP of LI 1 in the Class I group and for CI 2 of Class I group. P-value was significant only for SRP of LI 2 (p=0.002) and CN 1 (p=0.001) ; no other groups showed a positive correlation.

5. Discussion

Numerous studies have classified sagittal root position in different ways; Sze et al classified maxillary central incisors into three types – Type B, Type M, Type P wherein type B was when incisors were buccally placed, type M was when incisors were place in the 'middle' of the buccal and palatal cortical plate, and type P was when palatally placed. They further divided type B into three different subtypes. Similar method of classification was followed by Chung et al, Xu et al and Tao R et al.[12-14] Other studies have evaluated crown angulations on dental casts,[15,16]14 Wang et al studied sagittal angulation between long axis of teeth and long axis of alveolar bone.[8] In our study we classified the SRP according to Kan et al.[11]

In our study, of the 600 teeth evaluated, we found 46.6 % (CI – 41%, LI – 43%, CN – 56%) in the class I position, 36% were in class II position(CI – 47% , LI – 31% CN- 30%), 0.33% in class III position (CI – 0.3%, LI- 0%, CN - 0%); 17% were found in class IV position (CI – 11%, LI - 26%, CN – 14%). (**Table 1**)

The results signified that class III (root against the palatal cortical plate) was least common in our sample. Most of the central Incisors were found to be in Class I, wherein roots were inclined towards buccal cortical plate, or Class II position with roots in the middle of the alveolar bone housing without engaging the buccal or labial cortical plate. Lateral incisors were most frequently found in class II position while canines were mostly in the class I position (**Table 1**).

The frequency distribution of sagittal root position in 600 maxillary anterior teeth evaluated by Kan et al, there were 81.1%, 6.5%, 0.7% and 11.7% in class I, II, III and IV respectively. Suveera et al (11), found a similar frequency distribution as Class I was present in 85.10%, Class II – 10.5%, Class III – 0%, Class IV – 4.5%. Our findings were consistent with the findings of Kim et al, who found that maxillary incisors and canines were located more labially, Chung et al in their study found 82% were as type B, buccally placed, Xu et al[13] in their study found 95.4% were buccally placed, and 98.5% were buccally placed in the study by Tao R et al and Jung et al concluded that most teeth were inclined buccally in his study[14,19] so did Shreshtha R et al,[20] who also found buccally inclined maxillary anterior in Chinese population. All these aforementioned studies are done on different ethnic groups across the globe and most of the population are seen to have Class I to be the most prevalent type of inclination of anterior teeth.

However, of Jin et al in their study concluded that the maxillary anterior teeth were inclined towards the palatal aspect of the alveolar process.[21]

Further, a bilateral comparison was made in relation to the SRP of the anterior teeth. Central incisors were found to be similar to their counterpart only 64% percent of times, while they were dissimilar about 36% of times. Lateral Incisors were similar in about 76% of times and canines were similar 80% of times in our sample indicating a moderate correlation.

When Sagittal Root position was compared across gender, p -value was significant ly for LI 2, and CN 1. (**Table 3**). Glauckman et al concluded that neither sex nor tooth location were significant in terms of the frequency of classified positions.[7]

Anatomically, the palatal aspect of an extraction socket in the anterior maxilla is thicker and more cortical in nature than its labial counterpart, making the former a more suitable foundation for implant placement and the later more prone to bone resorption and/or collapse. In the Class I SRP, found in almost half of the teeth in our study, where the entire length of the root is in contact with the labial cortical plate and a considerable amount of bone is present on the palatal aspect for implant engagement to attain primary stability during IIPP renders this to be the most suitable position for implant placement. This palatal implant engagement leaves the labial bone intact and results in a small gap between the implant and the labial plate. This implant-socket gap is usually filled with bone grafting material so that an esthetic hard tissue contour can be maintained both vertically and horizontally.[22]

In Class III SRP, the entire length of the root engages the palatal cortical plate; therefore, the stability of the implant relies on its engagement in the available bone on the labial aspect. Labial bone has increased trabecular pattern and therefore higher tendency for labial resorption and thus peri-implant bone remodeling. Furthermore, labial concavities, occasionally observed near the base of the anterior maxilla, that can potentially lead to fenestration/perforation when labial implant engagement is attempted; This unfavourable situation of sagittal root inclination was found the least in our study. (0.33%)

In Class II SRP position, the amount of bone maybe sufficient to prevent labial and palatal bone fenestration but not enough for immediate implant stability. So when the clinician is considering IIP in such a site, amount of bone beyond the socket will be helpful for implant stability. (36% prevalence in present study).

As also, following extraction in Class IV, there is a limited amount of bone to ensure implant stability. Inorder to increase the predictability of the treatment, adjunctive bone grafting procedures are often necessary prior to implant placement.[23] Therefore, a Class IV SRP is considered by most authors to be a contraindication for IIPP. These results emphasize the importance of CBCT during diagnosis and treatment planning for implants, especially in maxillary anterior region, to identify these kinds of discrepancies. CBCT is an important and a proven adjunct to implant treatment planning.[24-26] Precise assessment and preoperative planning will allow clinicians to appropriately recognize sites that are favourable for IIPP (Class I SRP), sites that are more technique sensitive and entail additional attentions (Class II and Class III SRP), and sites that are contraindicated for IIPP, ie, that require hard and/or soft tissue augmentation prior to implant placement (Class IV SRP).

6. Conclusion

1. Almost half of the maxillary anterior teeth (46.6%) were in Kan et al Class I favourable position. Unfavourable Class III position was found to be least prevalent (0.33%) in the Indian population.
2. Bilateral comparison showed 80% similarity in CN, 76% similarity in LI and 64% similarity in CI.
3. SRP was not significantly different across the gender except in LI 2 and CN 1.

7. Source of Funding

8. Conflict of Interest

None.

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