Original Research Article

Measurement of inter radicular bone width in different growth patterns for determining safe zone for placement of miniscrew implants – A cone beam computed tomography study

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ABSTRACT

Aim: To measure the inter-radicular spaces in both arches for miniscrew implant placement and to determine the most reliable sites using CBCT.

Materials and Methods: A CBCT radiograph was taken for 75 subjects that met with inclusion criteria. They were divided into 3 categories- Hypodivergent, average, and hyperdivergent group. Images were calibrated by using software and printed as a film. Interradicular space on the right side of the jaw was measured in the sagittal plane after assuming the jaw to be symmetrical. Bucco-lingual and mesiodistal width were measured up to desired bone levels.

Results: In vertical growth pattern, in posterior maxilla highest mesiodistal width between 2nd premolar and 1st molar at 7mm. In the mandible, it was between the 1st and 2nd molar at 11mm. In horizontal growth pattern, in posterior maxilla highest mesiodistal width between 1st and 2nd premolar, and mandible it was between 1st and 2nd molar at 11mm. In average growth pattern, in posterior maxilla highest mesiodistal width between 2nd premolar and 1st molar and 1st molar at 7mm. In the mandible, it was between the 1st and 2nd molar at 11mm.

Conclusion: The importance of the relationship between the growth pattern and the availability of inter radicular space may aid the clinician in planning appropriate surgical sites for miniscrew implant placement.

1. Introduction

One of the most challenging aspects of orthodontic treatment is "Anchorage control". As described by Archimedes (Greek philosopher), "give me a place to stand and I will move the earth". He was a pioneer in the field of mathematics and mechanics and presented with anchorage problems much earlier than the clinicians faced it.[1] Anchorage has been defined as "the resistance to the forces generated against the active component of an orthodontic appliance". Simply, it means resistance to displacement. There are two elements of orthodontic appliance. One is the active tooth movement itself and another is the resistance elements.[2] Anchorage abides by Newton's third law which means every action (force) has an equal and opposite reaction. To sum up, all anchorage elements are relative,

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and all resistance forces are comparative. Various elements that provide orthodontic anchorage include the teeth, hard palate, head, neck, and implants.[3]

The Temporarily placed Miniscrew for orthodontic anchorage was mentioned for the first time in 1997 by Kanomi followed by the invention of more advanced screw designs.[4] Temporary anchorage devices (TADs), like mini-plates, mini-screw, micro-screw, micro-implants were advantageous because of their smaller size that can be placed easily at various implant sites. Also, surgical placement of mini-implants was easy since it does not require full flap retraction and can be loaded immediately. Thus, these were more popular than endosseous implants as a means of anchorage device for orthodontic procedures.[5] Though, miniscrews had several advantages yet they had some limitations.

Anchorage through miniscrew was limited by position and angulation of dental roots as well as inter-radicular space.

There were certain recommendations for the safe placement of miniscrews. To preserve periodontal health, a minimum of 1mm alveolar bone is recommended around the miniscrew. Therefore, a total of 3mm or larger inter radicular space is required for safe placement of miniscrew when the diameter of miniscrew and alveolar bone clearance is taken into consideration.[6] 6 The maxilla was a more suitable site for placement of mini-implants due to its sufficient bone quantity and tooth roots were more widely placed in it. Thus, Maxilla offered a higher success rate.[7] Several studies determined the safe site in inter radicular bone for the placement of miniscrews. These sites were called "safe zones". Moreover, the availability of inter radicular space was different for a different endoskeletal pattern. The inter radicular space was larger in the maxilla in patients with Class II Skeletal pattern as compared to Class III skeletal pattern and vice versa for mandibular jaw.[8] Also, inter-radicular bone availability also depends on gender and age. Studies show that Males and population older than 18 years of age have a larger buccal and lingual cortical bone thickness in both the jaws.[9] To plan miniscrew placement, Panoramic and periapical radiographs were not recommended as they provided two-dimensional images. Computed cone-beam tomography was preferred to obtain volumetric data to plan the mini-screw placement owing to its three-dimensional imaging, low cost, and relatively low radiation dose.[10] Thus, our aim of this study was to measure the inter-radicular spaces in the anterior and posterior region on the right side of the maxillary and mandibular jaw and to determine the most reliable sites for miniscrew placement using Cone-beam computed tomography.

2. Material and Methods

The sample of 75 subjects was selected and divided into 3 groups with 25 subjects in each group. A signed informed consent form was taken in English or Marathi language. Initially, each subject was thoroughly examined clinically according to inclusion and exclusion criteria.

2.1. Inclusion criteria

1. Full complement of erupted teeth excluding the third molars

2.2. Exclusion criteria

1. History of orthodontic or prosthodontic treatment
2. Dental arches with severe crowding or rotation
3. Missing teeth, periodontal diseases, and any pathology affecting the jaw will be excluded
4. Craniofacial deformity
5. Visually asymmetric jaw

A lateral cephalometric radiograph was taken for all subjects to categorize them in 3 different groups depending upon their relation of the mandibular plane (Go-Gn) to the SN plane according to Steiner analysis. Subjects were categorized into hypodivergent group when mandibular plane measured <28 degrees, average group when the measurement was between 28 degrees to 32 degrees, and hyperdivergent group when the measurement was >32 degrees. Advanced active pixel CMOS sensor, vibration-free motion kodak (8000), the digital radiographic unit was used to take the lateral digital cephalometric radiographs of the subjects involved in the study.

The patients were guided and then instructed to stand in a natural head position (NHP). Calibrated radiographic images were transferred in the software and 8x10" film was obtained and used for determining mandibular plane according to Steiner's analysis. After landmark identification, the SN plane, the mandibular plane, was drawn according to Steiner's analysis which was the most important step to determine the growth pattern of the patients. After determining the growth pattern of the patients, they were divided into 3 groups according to the measurement of the mandibular plane angle. To avoid any intraobserver error, a single operator performed all the tracings in a standardized manner. The CS9300 (Carestream 9300), CBCT unit of "Carestream Dental" company U.S.A was used to take the Cone Beam Computed Tomography of the subjects involved in the study. The CS 9300 provides more control in limiting radiation exposure to the patients. Pre-treatment Cone Beam Computed Tomography (CBCT) scans were taken with a single 3600 rotational scan time of 20 seconds (Actual exposure time 8 to 9 seconds), with 90KV, 5mA. Assuming subjects to be bilaterally symmetrical, the right-sided jaw of each subject was measured. The Digital Imaging and Communication in Medicine (DICOM) multi-files of each scan were imported into CS 3D imaging software for analysis. Each image was oriented in three planes of place so that morphological

Table 1: Mean ±SD values of all Growth Patterns inPosterior Maxilla

Location Maxilla	Growth Pattern	3mm	5mm	7mm	9mm	11mm
1st Premolar to 2nd Premolar (M-D)	Average	1.91200± .680270	2.17600± .679632	2.37200± .687095	2.60400± .901147	2.96800± 1.057402
	Vertical	1.88400± 0.496387	2.12800± 0.555668	2.25600± .740540	2.17200 ± 0.679166	1.95200± .947857
	Horizontal	2.67200 ± .573382	2.86800 ± .739775	3.01200± 1.001382	2.93600 ± 1.432911	2.22800 ± 1.822434
1st Premolar to 2nd Premolar (B-L)	Average	9.68800± 1.100500	9.62400± 1.114406	9.64400± 1.332629	9.92800± 1.514243	10.44400± 1.858333
	Vertical	9.76400 ± .858235	9.63600± 1.111261	9.35200 ± 1.616869	9.54000± 1.925920	8.52400 ± . 3.702958
	Horizontal	9.98000 ± .925563	9.94800 ± .855434	9.64800 ± 2.238884	8.98400 ± 3.486842	7.49600 ± 5.365436
2nd Premolar To 1st Molar (M-D)	Average	1.82400± .540278	2.05200± .473568	2.31600± .883968	2.40000± 1.565514	1.44000± 1.879716
	Vertical	2.37600 ± .513387	2.58400 ± .709272	2.20000 ± 1.275082	1.73200 ± 1.541568	.77600 ± 1.268621
	Horizontal	2.92000 ± .627163	2.82000 ± 1.170826	2.34800 ± 1.752408	1.69200 ± 2.221471	1.16800 ± 1.942661
2nd Premolar To 1st Molar (B-L)	Average	11.08400± .892412	11.36400± 1.048761	10.93200± 3.485652	9.08800± 5.334192	5.22400± 6.593322
	Vertical	11.06000 ± 1.635797	11.36000 ± 1.166905	8.92000 ± 4.663421	6.90800 ± 5.863511	3.72800 ± 5.582750
	Horizontal	11.02800 ± .954603	10.39200 ± 3.294303	7.96000 ± 5.669362	4.94000± 6.224950	3.60800 ± 5.995201
1st Molar To 2nd Molar (M-D)	Average	1.85600± 1.195854	1.74400± .537804	1.80800± .792107	1.26000± 1.369306	.68800± 1.155898
	Vertical	2.27200 ± .501265	2.13200 ± .412028	1.48800 ± 1.394131	1.01600 ± 1.416769	.37200 ± 1.065176
	Horizontal	2.59200 ± .753282	2.33200 ± .772291	1.87600 ± 1.300410	1.19200 ± 1.298050	.28800 ± .996795
1st Molar To 2nd Molar (B-L)	Average	13.03200± 1.288319	13.56400± 1.104868	12.76400± 3.995819	7.07600± 6.962057	3.87600± 6.420104
	Vertical	13.32400 ± 2.109163	13.66800 ± 2.022935	7.24800 ± 6.746179	4.64000 ± 6.486268	1.84400 ± 5.241428
	Horizontal	13.66800 ± .962081	14.34000 ± 1.126203	11.95200± 6.178263	8.58800 ± 7.816719	1.28000 ± 4.430199

analysis of dentoalveolar structures could be done in the Sagittal plane.

A total of 6 interradicular sites were examined in each experimental subject. In the selected patients, the right side of maxillary and mandibular CBCT sectional scan was done using Carestream 9300 machine. Buccolingual width was measured from buccal cortical plate to palatal/lingual cortical plate at 3mm, 5mm, 7mm, 9mm, 11mm, and data were collected in tabulated form. Mesiodistal width measurements from the alveolar crest up to desired bone level were performed.

3. Results

In vertical growth pattern, in posterior maxilla highest mesiodistal width between 2nd premolar and 1st molar at 7mm. in mandible, it was between 1st and 2nd molar at 11mm. (Tables 1 and 2)

In horizontal growth pattern, in posterior maxilla highest mesiodistal width between 1st and 2nd premolar, and mandible it was between 1st and 2nd molar at 11mm. (Tables 3 and 4)

In average growth pattern, in posterior maxilla highest mesiodistal width between 2nd premolar and 1st molar and 1st molar at 7mm., in mandible, it was between 1st and 2nd molar at 11mm. (Tables 5, 6 and 7)

4. Discussion

In this study, Interradicular distance between 1st and 2nd premolar, 2nd premolar and 1st molar as well as between 1st and 2nd molar was calculated in both the arches. The Cone beam computer tomography was used in this study. Both mesiodistal, as well as buccolingual distances, were measured. Significance difference between groups was found between the inter radicular bone values of maxillary

Table 2: Mean ±SD values of all Growth Pattern In theposterior Mandible

Location Mandible	Growth Pattern	3mm	5mm	7mm	9mm	11mm
1st Premolar to 2nd Premolar (M-D)	Average	2.12400± .639844	2.62800± .685881	3.26400± .781494	3.54400± .904655	4.13600± 1.219248
	Vertical	2.50400 ± .836401	3.15200 ± 1.144232	3.45200 ± 1.432399	4.06000 ± 1.946150	4.19200 ± 1.866351
	Horizontal	2.76800 ± .759232	3.23600 ± .860659	3.62000 ± 1.051190	3.90000± 1.156864	4.23200± 1.241545
1st Premolar to 2nd Premolar (B-L)	Average	9.44800± 1.330764	9.90000± 1.362901	10.38000± 1.379915	10.57600± 1.241061	.10.54400 ± .943433
	Vertical	8.04800 ± .897738	8.13600 ± .791033	8.26000± .505800	8.14800 ± 1.262973	8.62000± 1.119151
	Horizontal	8.67600 ± 1.639685	9.46400 ± 1.514618	9.62000 ± 1.430326	9.86800 ± 1.553416	10.04800 ± 1.580643
2nd Premolar To 1st Molar (M-D)	Average	2.04800± .810411	2.27200± .825893	2.71600± 1.066802	3.25600± 1.013279	4.18400± 1.097603
	Vertical	2.76400± .417213	3.15200± 449184	3.36000 ± .512348	3.84400 ± .797956	4.39600 ± 1.060456
	Horizontal	3.12800 ± .620161	3.34800 ± .641041	3.75600 ± .797956	4.12000 ± .920145	4.52000 ± .901388
2nd Premolar To 1st Molar (B-L)	Average	10.29600± 1.084159	10.95600± 1.175472	11.37600± 1.227219	11.67200± 1.031391	11.66000± 1.181454
	Vertical	9.60800 ± .783113	9.92400 ± .800666	9.94800 ± .855921	10.14800 ± .895414	10.13200 ± .888219
	Horizontal	10.38000 ± 1.535144	10.55600 ± 1.228509	10.87200 ± 1.468139	10.93600 ± 1.527492	11.13200 ± 1.654721
1st Molar To 2nd Molar (M-D)	Average	2.60000± .763217	2.72800± .948912	3.45600± 1.070078	4.12000± 1.368698	4.76000± 1.594261
	Vertical	3.30000 ± .632456	3.53200 ± .981377	4.11600± 1.266452	4.60400 ± 1.567503	5.08800 ± 1.958171
	Horizontal	3.56000 ± .878446	4.12000 ± 1.084743	4.53600 ± 1.112010	5.08400 ± 1.186620	4.96000 ± 2.008524
1st Molar To 2nd Molar (B-L)	Average	12.20400± 1.628261	12.97600± 1.336750	13.63600± 1.394895	13.78800± 1.528703	13.14800± 1.212820
	Vertical	11.42400 ± .974372	12.26800 ± 1.236837	12.93200 ± 1.567035	13.04000 ± 1.821172	12.66000 ± 1.952349
	Horizontal	11.40400 ± 1.001865	12.65200 ± .855434	13.26400 ± 1.094638	13.89200 ± 1.494969	13.69200 ± 1.653007

2nd premolar and 1st molar region and between 1st and 2nd maxillary molars. Thus, the null hypothesis for this study was rejected. In the posterior maxilla, the greatest amount of mesiodistal inter radicular bone was found between 1st and 2nd premolar at 11mm, 2nd premolar and 1st molar at 9mm, 1st molar and 2nd molar at 3mm apically from the alveolar crest. Moreover, the highest buccolingual inter radicular bone was found between 1st and 2nd premolar at 11mm, 2nd premolar and 1st molar at 5mm, and between 1st and 2nd molar at 5 mm. In the posterior mandible, the greatest amount of mesiodistal inter radicular bone was found at 11mm and buccolingually at 9 mm between all the teeth. It can be said that the inter radicular bone is greater apically than towards the alveolar crest. The least amount of bone was between maxillary 1st and 2nd molar (1.8 mm at 3mm depth from alveolar crest) and between mandibular 2nd premolar and molar (2.04 mm at 3mm depth for alveolar crest).

In the study conducted by Poggio, the greatest mesiodistal inter radicular bone was between the 2nd premolar and 1st molar (5.5 mm SD 1.3) at 5mm from the alveolar crest. Lesser mesiodistal space is available on the buccal side than the lingual aspect. Buccopalatally, the greatest amount of inter radicular bone was found between 1st and 2nd molars (14.1 mm SD 1.1) at 5 mm depth from the alveolar crest. Thus, it was concluded that the palatal aspect had more sites for mini-implant placement due to great bone availability.[8]

Mini implant size varies around 5-6 mm in length and 1-1.2 mm in diameter. Ideally, 1 mm of sound bone is needed to maintain periodontal health. Thus, a minimum of 3.2 mm of inter radicular bone is required for placement of the mini-implant for orthodontic anchorage.[11] The insertion site for placement of the mini-implant depends

Table 3: Comparisonof mean growth pattern at different level of alveolar height among Maxillary 1st pm -2nd Pm in mesio-distal width of vertical growth pattern.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.413	4	.603	1.225	.304
Within Groups	59.118	120	.493		
Total	61.532	124			

a. AXIS = Vertical, JAW = Maxillary, ORIENTATION = M-D, TEETH = 1st Pm-2nd Pm

Multiple Comparisonsa

Dependent Variable: Growth Pattern In mm

Tukey HSD

(I) AT MM	(J) AT MM	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
3mm	5mm	-.244000	.198525	.734	-.79385	.30585
3mm	7mm	-.372000	.198525	.337	-.92185	.17785
3mm	9mm	-.288000	.198525	.596	-.83785	.26185
3mm	11mm	-.068000	.198525	.997	-.61785	.48185
5mm	7mm	-.128000	.198525	.967	-.67785	.42185
5mm	9mm	-.044000	.198525	.999	-.59385	.50585
5mm	11mm	.176000	.198525	.901	-.37385	.72585
7mm	9mm	.084000	.198525	.993	-.46585	.63385
7mm	11mm	.304000	.198525	.544	-.24585	.85385
9mm	11mm	.220000	.198525	.802	-.32985	.76985

a. AXIS = Vertical, JAW = Maxillary, ORIENTATION = M-D, TEETH = 1st Pm-2nd Pm

Table 4: Comparison of mean growth pattern at different level of alveolar height among Maxillary 2nd Pm and 1st molar- in mesio-distal width of vertical growth pattern.

ANOVA^a

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	51.760	4	12.940	10.144	**<0.001**
Within Groups	153.079	120	1.276		
Total	204.839	124			

a. AXIS = Vertical, JAW = Maxillary, ORIENTATION = M-D, TEETH = 2nd Pm -1st M

Table 5:

Multiple Comparisons^a

Dependent Variable: GROWTH PATTERN IN mm Tukey HSD

(I) AT MM	(J) AT MM	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
3mm	5mm	-.208000	.319457	**.966**	-1.09280	.67680
3mm	7mm	.176000	.319457	**.982**	-.70880	1.06080
3mm	9mm	.644000	.319457	**.265**	-.24080	1.52880
3mm	11mm	1.600000*	.319457	**<0.001**	.71520	2.48480
5mm	7mm	.384000	.319457	**.750**	-.50080	1.26880
5mm	9mm	.852000	.319457	**.065**	-.03280	1.73680
5mm	11mm	1.808000*	.319457	**<0.001**	.92320	2.69280
7mm	9mm	.468000	.319457	**.587**	-.41680	1.35280
7mm	11mm	1.424000*	.319457	**<0.001**	.53920	2.30880
9mm	11mm	.956000*	.319457	**.027**	.07120	1.84080

*. The mean difference is significant at the 0.05 level.

a. AXIS = Vertical, JAW = Maxillary, ORIENTATION = M-D, TEETH = 2nd Pm -1st M

11. Gómez AC, Núñez EG, Querol EU. «Safe» areas with more bone quantity for inter-radicular mini-implant placement in the buccal cortical of the upper maxilla in periodontally compromised patients. *Revista Mexicana de Ortodoncia*. 2015;3(3):e148–53. doi:10.1016/j.rmo.2016.03.040.

12. Chaimanee P, Suzuki B, Suzuki EY. "Safe Zones" for miniscrew implant placement in different dentoskeletal patterns. *Angle Orthod*. 2011;81(3):397–403. doi:10.2319/061710-111.1.

13. Echarri P, Favero L. Ortodoncia & microimplantes. Ripano; 2012.

14. Moslemzadeh SH, Sohrabi A, Rafighi A, Kananizadeh Y, Nourizadeh A. Evaluation of Interdental Spaces of the Mandibular Posterior Area for Orthodontic Mini-Implants with Cone-Beam Computed Tomography. *J Clin Diagn Res*. 2017;11(4):ZC09–ZC12. doi:10.7860/JCDR/2017/25436.9520.

15. Ono A, Motoyoshi, Shimizu N. Cortical bone thickness in the buccal posterior region for orthodontic mini-implants. *Int J Oral Maxillofac Surg*. 2008;37(4):334–40.

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