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Buccal cortical bone thickness for mini-implant placement: A CBCT study

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Abstract

The use of mini-implants in orthodontics as a temporary anchorage device has increased manifolds because of its obvious advantage of absolute anchorage and elimination of compliance. One of the major factors governing stability of the mini-implant is the buccal cortical bone thickness. The aim of this study was to assess the cortical bone thickness changes in interradicular locations where minis crews are commonly placed. Collection of CBCT scans included contributions from all dental specialties where 60 study quadrants (30 maxillary and 30 mandibular) were selected from the patient records and cortical bone thickness was collected at three interradicular locations in each jaw at levels of 4mm and 6mm. The three-dimensional CBCT scans were imported into the Anatomage software and evaluated at a 0.33-voxel resolution where the images were aligned for measurement of bone thickness. Results concluded that buccal cortical bone thickness was greater at 6mm than 4mm for both the jaws. Also, not all sites have a minimum of 1mm thickness, hence knowledge of bone thickness at the site of mini-implant placement would be useful to attain more stability.

Keywords: Cortical Bone Thickness, Mini Implants, CBCT.

Introduction

The use of mini-implants in orthodontics as a temporary anchorage device has increased manifolds because of its obvious advantage of absolute anchorage and elimination of compliance issues. [1,2] A mini-implant, which ranges in diameter from 1.5 mm to 3 mm and in length from 6 mm to 11 mm, can be placed in the axial plane between teeth without causing damage to them. Mini implants are commonly used in the mouth for tooth up righting,[3] retraction,[4] extrusion, [5] intrusion, [6] and

stabilization [7]. One of the major factors governing stability of the mini-implant is the buccal cortical bone thickness. A minimum of 1mm of cortical bone was shown to be necessary for increasing success rates.[8] This study showed that knowledge of the thicknesses of cortical bone throughout the jaws is directly linked to the success of mini-implants. Most orthodontic practices are limited in their radiographic imaging to pan tomographic, cephalometric and intraoral units. Computed tomography (CT) images can provide accurate measurements of small areas in bone to determine where anchors can best be placed. [9-12] The purpose of this study is to investigate cortical bone thickness on cone beam computed tomography (CBCT) images of patients in interradicular areas commonly used for mini screw implant placements.

Aim & objective

Aim

To assess the cortical bone thickness changes in interradicular locations where mini screw implants are placed.

Objectives:

- To evaluate and compare changes in cortical bone thickness in horizontal and vertical plane.
- To evaluate and compare the changes in cortical bone thickness in maxilla and mandible.

Material & method

The study was conducted in the department of orthodontics and dentofacial orthopedics of Ahmedabad dental college and hospital, Ahmedabad, India. 60 study quadrants (30 maxillary and 30 mandibular) were selected from 30 CBCT scans and were examined retrospectively to evaluate the cortical bone thickness in commonly chosen areas for the placement of mini-implants. The mean (± standard deviation) age in the study population was 36 years (±16.3) (median=29). The study subjects were 12 women and 18 men.

Inclusion criteria

- The entire maxilla and mandible should be present in the scan with fully erupted permanent dentition without any missing or congenitally absent teeth.
- The subjects selected showed no presence of periodontal disease.

Exclusion criteria

- Subjects having edentulous spaces or mixed dentition, significant cuspal wear, extensive restorations, or prosthetics.
- Individuals undergone orthodontic treatment, having any craniofacial anomalies, marked jaw asymmetries or TMJ abnormalities.

Method

A CBCT scan of maxilla and mandible is taken and a cross sectional view of the scan is selected. A line is mapped to view the cross section of the maxillary alveolar crest. The three-dimensional CBCT scans were imported into the Anatomage software and evaluated at a 0.33-voxel resolution. The images were all aligned using a standard method for accurate measurements of bone thickness. Cortical bone thickness (in millimeters) was collected at three interradicular locations in each jaw at levels of 4 mm (H_1) and 6 mm (H_2) apical to the alveolar crest:

(a) between the canine and first premolar,
(b) between the first and second premolars,
(c) between the second premolars and first molars.

Measurements were identified by grid number 1 to 3 at each location as following:

Point (1) the most mesial point without violating the periodontal ligament space at H1 and H2. Point (2) the midpoint at H1 & H2. Point (3) the most distal point

without violating the periodontal ligament space at h1 & h2.For mandibular jaw, a line is mapped viewing the cross section of mandibular alveolar crest and cortical bone thickness is evaluated at locations analogous to those used for maxilla.

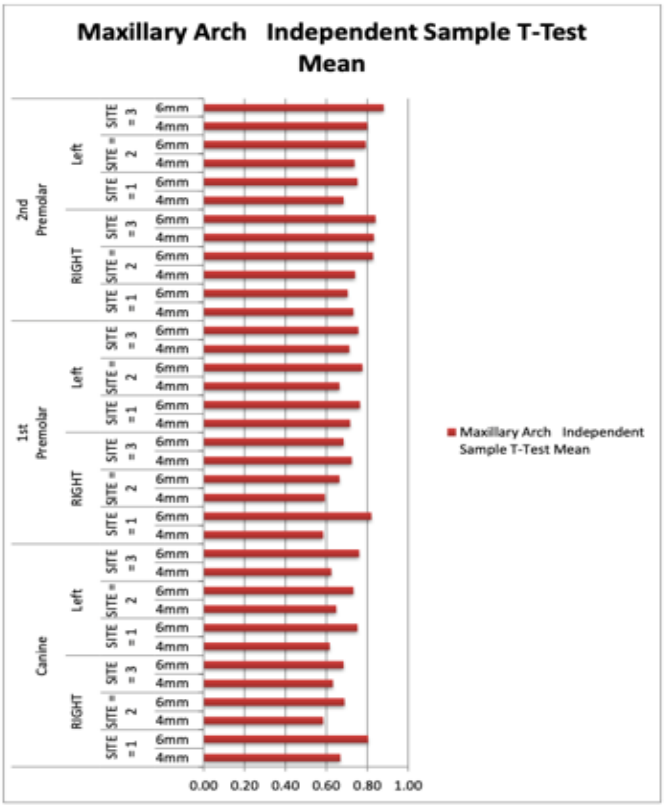
Statistical analysis:

All statistical analyses were performed using the SPSS software package (SPSS for windows 8, version 18.0). For each variable, the arithmetic mean and standard deviation were calculated.

Results

Table 1 shows the mean difference in cortical bone thickness between sites 4mm and 6 mm from the alveolar crest in the maxilla. Bone thickness was comparatively higher at 6mm compared to 4mm (graph 1).

Table 2 shows the mean difference in cortical bone thickness between sites 4mm and 6mm from the alveolar crest in the mandible. Bone thickness was comparatively higher at 6 mm compared to 4mm (graph 2).



Graph 1

Maxillary Arch Independent Sample T-Test

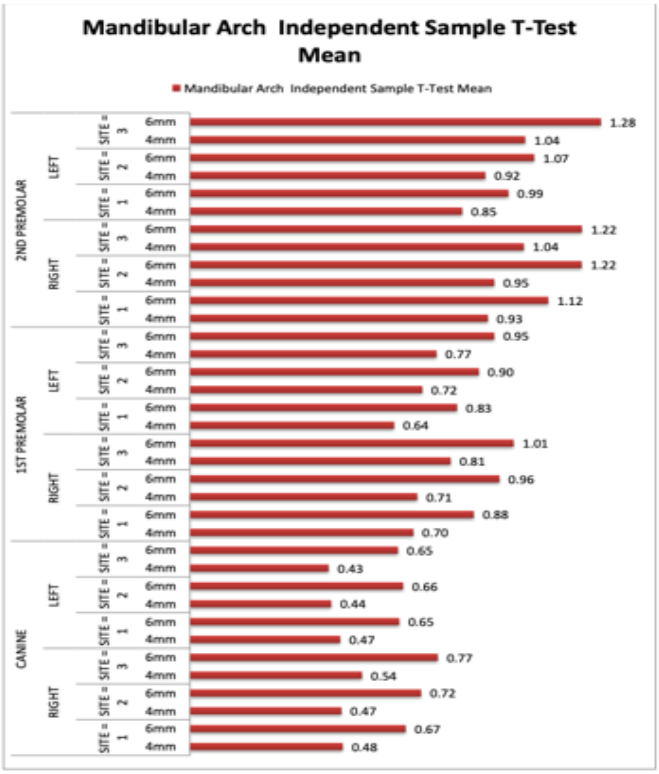
			LENGTH	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	P Value
Canine	RIGHT	SITE = 1	4mm	25	0.67	0.30	0.06	-0.14	0.135
			6mm	25	0.80	0.33	0.07		
		SITE = 2	4mm	25	0.58	0.23	0.05	-0.10	0.139
			6mm	25	0.69	0.26	0.05		
		SITE = 3	4mm	25	0.63	0.26	0.05	-0.05	0.456
			6mm	25	0.68	0.23	0.05		
	Left	SITE = 1	4mm	25	0.62	0.24	0.05	-0.14	0.044
			6mm	25	0.75	0.28	0.06		
		SITE = 2	4mm	25	0.65	0.20	0.04	-0.08	0.223
			6mm	25	0.73	0.27	0.05		
		SITE = 3	4mm	25	0.62	0.32	0.06	-0.14	0.104
			6mm	25	0.76	0.26	0.05		
1st Premolar	RIGHT	SITE = 1	4mm	25	0.58	0.17	0.03	-0.24	0.001
			6mm	25	0.82	0.27	0.05		
		SITE = 2	4mm	25	0.59	0.17	0.03	-0.07	0.260
			6mm	25	0.66	0.26	0.05		
		SITE = 3	4mm	25	0.72	0.23	0.05	0.04	0.496
			6mm	25	0.68	0.18	0.04		
	Left	SITE = 1	4mm	25	0.72	0.23	0.05	-0.05	0.475
			6mm	25	0.76	0.24	0.05		
		SITE = 2	4mm	25	0.66	0.16	0.03	-0.11	0.056
			6mm	25	0.78	0.24	0.05		
		SITE = 3	4mm	25	0.71	0.20	0.04	-0.04	0.470
			6mm	25	0.76	0.23	0.05		
2nd Premolar	RIGHT	SITE = 1	4mm	25	0.73	0.30	0.06	0.03	0.724
			6mm	25	0.70	0.26	0.05		
		SITE = 2	4mm	25	0.74	0.22	0.04	-0.09	0.249
			6mm	25	0.83	0.31	0.06		
		SITE = 3	4mm	25	0.83	0.21	0.04	-0.01	0.920
			6mm	25	0.84	0.34	0.07		
	Left	SITE = 1	4mm	25	0.68	0.17	0.03	-0.07	0.251
			6mm	25	0.75	0.24	0.05		
		SITE = 2	4mm	24	0.74	0.20	0.04	-0.05	0.352
			6mm	25	0.79	0.20	0.04		
		SITE = 3	4mm	25	0.80	0.24	0.05	-0.08	0.436
			6mm	25	0.88	0.45	0.09		

Table 1

Mandibular Arch Independent Sample T-Test

			LENGTH	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	P Value
CANINE	RIGHT	SITE = 1	4mm	30	0.48	0.54	0.11	-0.20	0.123
			6mm	30	0.67	0.31	0.06		
		SITE = 2	4mm	30	0.47	0.46	0.09	-0.25	0.032
			6mm	30	0.72	0.32	0.06		
		SITE = 3	4mm	30	0.54	0.53	0.11	-0.24	0.070
			6mm	30	0.77	0.35	0.07		
	LEFT	SITE = 1	4mm	30	0.47	0.55	0.11	-0.18	0.211
			6mm	30	0.65	0.47	0.09		
		SITE = 2	4mm	30	0.44	0.43	0.09	-0.22	0.079
			6mm	30	0.66	0.45	0.09		
		SITE = 3	4mm	30	0.43	0.41	0.08	-0.22	0.085
			6mm	30	0.65	0.46	0.09		
1ST PREMOLAR	RIGHT	SITE = 1	4mm	30	0.70	0.51	0.10	-0.19	0.128
			6mm	30	0.88	0.34	0.07		
		SITE = 2	4mm	30	0.71	0.39	0.08	-0.26	0.018
			6mm	30	0.96	0.35	0.07		
		SITE = 3	4mm	30	0.81	0.49	0.10	-0.20	0.184
			6mm	30	1.01	0.54	0.11		
	LEFT	SITE = 1	4mm	30	0.64	0.48	0.10	-0.20	0.129
			6mm	30	0.83	0.42	0.08		
		SITE = 2	4mm	30	0.72	0.43	0.09	-0.18	0.138
			6mm	30	0.90	0.39	0.08		
		SITE = 3	4mm	30	0.77	0.48	0.10	-0.18	0.191
			6mm	30	0.95	0.48	0.10		
2ND PREMOLAR	RIGHT	SITE = 1	4mm	30	0.93	0.51	0.10	-0.19	0.217
			6mm	30	1.12	0.55	0.11		
		SITE = 2	4mm	30	0.95	0.46	0.09	-0.27	0.034
			6mm	30	1.22	0.42	0.08		
		SITE = 3	4mm	30	1.04	0.59	0.12	-0.18	0.275
			6mm	30	1.22	0.56	0.11		
	LEFT	SITE = 1	4mm	30	0.85	0.48	0.10	-0.14	0.346
			6mm	30	0.99	0.58	0.12		
		SITE = 2	4mm	30	0.92	0.43	0.09	-0.15	0.292
			6mm	30	1.07	0.56	0.11		
		SITE = 3	4mm	30	1.04	0.62	0.12	-0.24	0.228
			6mm	30	1.28	0.74	0.15		

Table 2



Graph 2

Comparison was also made between cortical bone thickness at sites 1,2 and 3 at 4mm and 6mm for maxilla and mandible, but difference in bone thickness was not statistically significant.

Discussion

One of the challenges in relation to the use of mini-implants is to determine an appropriate and exact location for these mini- implants. Various criteria have been defined in this context, consisting of compatibility, biomechanical design, sufficient attention not to inflict traumas to roots, arteries, veins and nerves, and lastly adequate thickness of the cortical bone for the stability of the implant. [13] Several studies have proposed a variety of methods for assessing bone thickness, but in recent years, the use of a CBCT scan has been common for preoperative quantitative and qualitative assessment of implant sites.[14] A large number of studies have shown that the cortical bone thickness is a vital factor in achieving stability for mini implants.[15] Although much is known about cortical bone thickness in the vertical and anterior-posterior dimension, little is known about whether cortical bone thickness varies in the mesial-distal sites between teeth. Even though it is safest to place mini screw implants directly in the middle of the interproximal site because of small interradicular spaces, in some clinical scenarios it can be advantageous to place the mini screw implants mesial or distal to the midpoint between two teeth. [16,17]

Insertion of the mini-implant at an oblique angle allows for the use of more space, reduces the possibility of root injury, and increases the surface area in contact with cortical bone. Placement in the attached or on the border between attached and unattached gingiva with thinner soft tissue is therefore preferable. The main criterion for stability of an implant is the quality and quantity of cortical bone and thin soft tissue.[18] In this study buccal cortical bone increases in thickness as the distance of the measurement points from the alveolar crest increases the mandible and the maxillary arches. This is no surprise since one would expect cortical bone thickness to increase from the alveolar bone to the basal bone. In both jaws buccal cortical bone thickness increases at the 6-mm mark than at the 4-mm mark in our study. It demonstrates that, to maximize cortical bone anchorage in the buccal segments, the mini-implant should be placed more than 4 mm apically from the alveolar crest. This means that most mini-implants in the buccal segments must be placed close to the mucogingival junction or perhaps even in mucosa. The null hypothesis was rejected, and there was a significant pattern of cortical bone thinning approaching the point bisecting two teeth although statistically not significant.[19] Because of the small interradicular spaces and risk of

root proximity, the safest strategy is most likely to place every mini screw implant in the middle of the interproximal site. In the present study it is found that the alveolar cortical bone thickness and density are greater in the mandible than in the maxilla. Same results were found by other authors that report a thicker and higher alveolar cortical bone in the lower jaw than in the upper jaw. Baumgaertel and hans observe a thicker buccal cortical bone in mandible [20].

Conclusion

Various studies have been done regarding the factors affecting stability of mini-implants. Cortical bone thickness at site of mini-implant is said to be the most important factor affecting stability. In our study – "a cone beam computed tomography study for buccal cortical bone thickness for mini-implant placement" we concluded that buccal cortical bone thickness was greater at a height 6mm than 4mm from the alveolar crest in both maxilla and mandible also no significant difference was found horizontally between sites. However, a limitation of this study is that only the bone quantity was assessed. The quality of bone surrounding the implant might also have an impact on implant stability. Further clinical studies are necessary to evaluate the quality of bone surrounding mini screws.

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