INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume 4, Issue 5)
Available online at: www.ijariit.com

Buccal cortical bone thickness of hyperdivergent and hypodivergent Bengali subjects in mandibular posterior region

Dr. Nilanjana Ghatak
rumu_ghatak@rediffmail.com
Department of Health and Family Welfare, Kolkata, West Bengal

Dr. Prasenjit Banerjee
prosenjit12@rediffmail.com
Guru Nanak Institute of Dental Sciences and Research, Kolkata, West Bengal

ABSTRACT

Forms and functions of structures are two interrelated things in the human body. Bones adapt to functional forces according to Wolf's law. Our jaw bones also follow the same law. Facial divergence has been related to forces of masticatory muscles. Whereas muscle forces have been related to the cortical thickness and facial divergence, limited research has been conducted relating cortical bone thickness to facial divergence. Objectives include to asses differences in dentoalveolar buccal cortical bone thickness between hyperdivergent and hypodivergent Bengali population in the mandibular posterior region. The aim is to provide reference data for orthodontists placing mini-screw implants for treatment purpose. No of subjects 40. Subjects with Frankfort mandibular plane angle more than 29° were classified as hyperdivergent and less than 21° were classified as hypodivergent. Age group is between 14 to 26 yrs.

Keywords— *Buccal cortical bone, Mandibular posterior region, Facial type, Bengali subjects, CBCT, Miniscrew placement*

1. INTRODUCTION

Orthodontic treatment depends highly on anchorage. Over the years skeletal anchorage has gained popularity in daily clinical practice over conventional anchorage Orthodontic mini implants are simple easy to use, cost-effective, and convenient for achieving absolute skeletal anchorage with an estimated success rate of 80% - 90%[20].

These parameters can be thoroughly evaluated by contemporary imaging techniques such as CT (Computed Tomography) and CBCT (Cone Beam Computed Tomography). These 3D methods present advantages over conventional 2D radiographic techniques e.g. cephalometric and panoramic radiographs by providing accurate reliable 3D information[3], which is mandatory for research purpose. High definition images of dent alveolar structures can be obtained at a significantly lower radiation dose compared to conventional imaging techniques. Unlike conventional X-ray (due to the divergence of the beam) CBCT (Cone Beam Computed Tomography) gives images without superimposition or distortion.

In recent years 3-dimensional analyses and measurement of jaws have become more common, especially for the morphology and cortical bone, the width of the cortical plate in the mandible. However, there is still a very small number of comprehensive studies showing how the width of cortical plates in maxilla and mandible as related to mini implant sites are affected by the different vertical patterns of the face. Most of the previous CBCT (Cone Beam Computed Tomography) studies were done at maxillary and mandibular posterior regions (distal to the canine). Again most of the previous CBCT (Cone Beam Computed Tomography) studies comparing vertical facial types have measured bone thickness at a single horizontal level from the alveolar crest. There is only one study done by Swasty et al.[28] that investigated cortical bone thickness at different horizontal levels from the alveolar crest in live patients with respect to different vertical facial dimensions. But they did not measure cortical thickness from any standard site, but just divided the distance from the height of the base of the mandible to the top of the alveolar crest, and measured from one third and two-thirds of this length.

2. AIMS AND OBJECTIVES

The objective of the study is to:

- Measure the thickness of buccal cortical bone at specified sites of the mandibular posterior region in Bengali hypodivergent and hyperdivergent subjects
- Compare subjects classified as hyperdivergent to subjects classified as hypodivergent.
- If cortical bone thickness varies between hyper and hypodivergent individuals, miniscrew implant placement procedure might also need to vary. If the bone is thinner in certain areas, then different treatment modalities can be considered, so that there is no loss of mini implants if they are an important part of the treatment plan.

3. MATERIALS AND METHODS

3.1 Study area

This cephalometric radiographic study was carried out in the Department of Orthodontics and Dentofacial Orthopaedics, Guru Nanak Institute of Dental Sciences and Research of Panihati, Kolkata - 114.

3.2 Study population

Samples selected from image archive of the institution.

3.3 Sample size

40

3.4 Sample selection

Inclusion criteria: Bengali patients aged between 14yrs to 26yrs. Patients have been divided into 2 groups (hypodivergent & hyperdivergent). Hypodivergent patients characterized by Frankfort mandibular plane angle < 21°.Hyperdivergent patients characterized by Frankfort mandibular plane angle > 29°.

Exclusion criteria

(i) No facial asymmetries
(ii) No cleft lip / palate
(iii) No impacted / missing teeth in measurement site
(iv) No periapical or periradicular pathologies or radio-lucencies of either periodontal or endodontic origin
(v) No severe facial or dental asymmetries
(vi) No vertical or horizontal alveolar bone loss
(vii) No significant medical history

3.5 Study Design

Cross-sectional.

3.6 Parameters studied

The buccal cortical bone thickness of mandible between

- Right first premolar and second premolar
- Right second premolar and first molar
- Right first molar and second molar

All parameters have been measured in every 1mm starting from 2mm from the highest point of the alveolar crest as only cortical bone is seen at the height of alveolar crest to the lower border of the mandible. Comparison between hypodivergent and hyper divergent patients have been done in 3 specified sites- 5mm, 10mm, and 15mm from the alveolar crest.

3.7 Study period

January 2015 to August 2016

3.8 Study tools

- CBCT (Myray Blue sky Machine, Conical, Variable-Field, H.R. Zoom, 90 Kvp, 10 Ma(max), Pulsed Emission).
- Nnt Viewer software.

3.9 Study techniques

CBCT images have been analysed using above mentioned software. Measurements were reassessed after 1 month at 5mm, 10mm, and 15mm from the alveolar crest.

Head orientation- FH plane parallel to the horizontal plane.

Vertical sections are taken in each interproximal region at the midpoint between two adjacent teeth. All distances measured are perpendicular to the vertical plane.

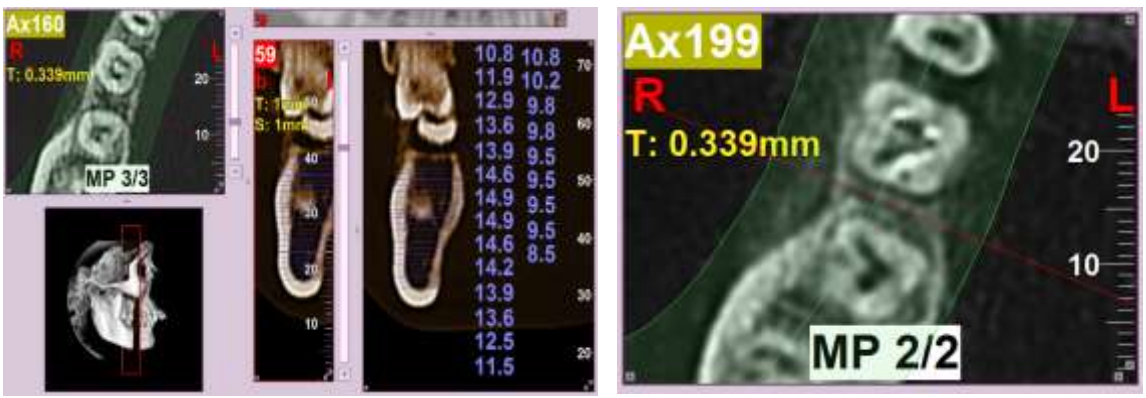

Fig. 1: Orientation

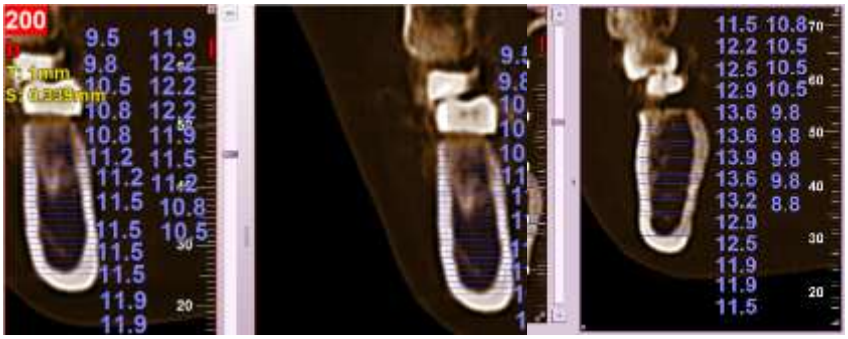

Fig 5: Alveolar ridge measurement of hyperdivergent subject at the interproximal region between mandibular Fig 6: Alveolar ridge measurement of hypodivergent subject at the interproximal region between 2nd premolar and 1st molar. Mandibular 2nd premolar and 1st molar.

4. STATISTICAL ANALYSIS

For statistical analysis, data were entered into a Microsoft excel spreadsheet and then analyzed by SPSS 20.0.1and GraphPad Prism version 5. Data have been summarized as mean and standard deviation for numerical variables and count and percentages for categorical variables. The median and the interquartile range have been stated for numerical variables that are not normally distributed. Student's independent sample's t-test was applied to compare normally distributed numerical variables.

Explicit expressions that can be used to carry out various *t*-tests are given below. In each case, the formula for a test statistic that either exactly follows or closely approximates a *t*-distribution under the null hypothesis is given. Also, the appropriate degrees of freedom are given in each case. Each of these statistics can be used to carry out either a one-tailed test or a two-tailed test. Once a *t* value is determined, a *p*-value can be found using a table of values from Student's t-distribution. If the calculated *p*-value is below the threshold chosen for statistical significance (usually the 0.10, the 0.05, or 0.01 level), then the null hypothesis is rejected in favor of the alternative hypothesis. p-value ≤ 0.05 was considered for statistically significant.

Distribution of MEAN cortical bone thickness at the sites 1, 2 and 3 in two groups (1 = 5mm from alveolar crest, 2 = 10mm from alveolar crest, 3 = 15 mm from alveolar crest)

Table 1: Distribution of MEAN cortical bone thickness in the interproximal region between right mandibular 1st & 2nd premolar

Buccal 45	Group	Number	Mean	SD	p-value
1	Hyper	20	1.4200	.2707	< 0.0001
	Hypo	20	2.0650	.1755	
2	Hyper	20	1.4000	.3554	< 0.0001
	Hypo	20	2.1550	.2188	
3	Hyper	20	1.9300	.2755	0.0012
	Hypo	20	2.2000	.2052	

Table 2: Distribution of MEAN cortical bone thickness in the interproximal region between right mandibular 2nd premolar & 1st molar

Buccal 56	Group	Number	Mean	SD	p-value
1	Hyper	20	1.8400	.2113	0.0002
	Hypo	20	2.0750	.1446	
2	Hyper	20	2.1200	.2331	0.0021
	Hypo	20	2.4700	.4131	
3	Hyper	20	2.0600	.3347	<0.0001
	Hypo	20	2.6400	.2234	

Table 3: Distribution of MEAN cortical bone thickness in the interproximal region between right mandibular 1st& 2nmolar

Buccal 67	Group	Number	Mean	SD	p-value
1	Hyper	20	1.8400	.3733	<0.0001
	Hypo	20	2.3850	.3100	
2	Hyper	20	2.2700	.2430	0.0003
	Hypo	20	2.6700	.3799	
3	Hyper	20	2.0600	.3778	0.7170
	Hypo	20	2.1200	.6303	

5. DISCUSSION

The present study found that buccal cortical bone thickness of the mandible is closely related to vertical facial types. In all measurement sites—cortical bone thickness in the low-angle subjects was significantly higher than in the high-angle subjects. Most of the previous CBCT studies comparing vertical facial types have measured bone thickness at a single horizontal level from

alveolar crest- while in the current study the buccal cortical bone thickness of hypodivergent and hyperdivergent individuals have been compared at 5mm, 10mm, and 15mm from the alveolar crest. The only study[28] that investigated cortical bone thickness at different horizontal levels from alveolar crest in live patients with respect to different vertical facial dimensions, unfortunately, did not measure cortical thickness from any standard site, but just divided the distance from the height of the base of the mandible to the top of the alveolar crest, and measured from one third and two thirds of this length, probably measuring the cortical thickness from a different height in each patient. In a study conducted by Horner et al[1], cortical bone thickness, alveolar ridge thickness, and medullary bone thickness had been measured only at 5 mm from alveolar crest in the interproximal region between right canine & 1st premolar, right 1st& 2nd premolar, right 2nd premolar & 1st molar, right 1st and 2nd molar- both in maxilla and mandible. They have found that mean buccal cortical bone thickness to be significantly higher in the interproximal region between maxillary 3-4; 4-5; 6-7 and mandibular 6-7; 5-6; 4-5. In the present study, the same regions in the mandible at 5 mm from alveolar crest have shown a statistically significant difference between hyperdivergent and hypodivergent individuals.

In the current study in general, the buccal cortical bone was thicker in hypodivergent than in hyperdivergent individuals.

5.1 In hypodivergent subjects

In the interproximal region between first and second premolar, buccal cortical bone and the alveolar ridge were found to be significantly thicker at all 3 sites Again between second premolar and first molar both buccal cortical bone and the alveolar ridge was significantly thicker in hypodivergent individuals. Lingual cortical bone was significantly thicker only at 5mm from the alveolar crest.

Between first and second molar, the buccal cortical bone was significantly thicker in hypodivergent subjects at all three sites. The differences of cortical bone thickness at different sites may be explained by masticatory function. Vertical facial development has been related to weak masticatory muscles[37]. Weakened masticatory muscles produce smaller bite forces, which leads to less strain on the associated bones[29,30,31,32,33].

Reason for the inconsistencies with other studies might be racial differences, use of cadavers, dry skulls, live patients, or different measurement sites. In the current study, the alveolar cortical bone thickness was measured from a height of 2 mm from the alveolar crest up to - in mandible-lower border of mandible on the CBCT data of live Bengali patients and compared at 5mm, 10mm and 15 mm from the alveolar crest.

Since cortical thickness is reported to be a major factor in the success of mini-implants, it is important to use an accurate and reproducible method to measure it, taking mini-implant placement sites into consideration [2, 34]. Masumoto et al[25] measured the cortical bone width at 10 vertical levels starting from the lower border of the mandible and showed that some of these variables changed with each facial type, whereas other variables showed no change with differing facial characteristics. To be able to evaluate cortical bone thickness for the purpose of the suitability of mini-implant sites, measurements should be made from the clinically favourable area for the mini-implants. This favourable area lies in the attached gingiva,[35] considering the lower probability of inflammation, and is approximately 4 to 6 mm from the alveolar crest or the cementoenamel Junction[18,36,37,38]. Ono et al deduced that the distance from the alveolar crest to the mucogingival junction could be 2 to 4 mm in the maxilla, and this height should be the border so as not to irritate the nonkeratinized tissue and cause inflammation around the mini-implant. In the current study, the alveolar cortical bone thickness was measured from a height of 2 mm from the alveolar crest.

6. LIMITATIONS

- This study involved the limited sample size-subjects were limited to the patients in the dental records archive from Guru Nanak Institute of Dental Science and Research.
- Sex differences were not studied.
- All measurements were taken at the right side only, as the previous study has shown no difference between right and left side[24,26,28].

7. CONCLUSION

This study used the improved imaging capability of the CBCT to investigate the relationship between vertical facial patterns and mandibular posterior region tooth-alveolar morphology in the Bengali population. Overall, statistically significant differences were found between the facial types. The present study confirms that buccal cortical bone thickness at mini-implant sites is lower in high-angle patients than in low-angle patients; this would bring a higher risk of loss of implants in these patients. So, it is an orthodontists' responsibility to take precautions in patients with less cortical bone thickness (i.ehyperdivergents) so that they do not lose their mini-implants if they are an important part of our treatment plan. These precautions could be to use thicker miniscrews, to emphasize and monitor oral hygiene more strictly, possibly to place the miniscrews in a more angulated position to take advantage of the longer diagonal bone surface or to use miniplates.

8. BIBLIOGRAPHY

[1] Keri A.Horner, Rolf G.Behrents, Ki Beom Kim and Peter H.Buschang. Cortical bone and ridge thickness of hyperdivergent and hypodivergent adults. Am J Orthod Dentofacial Orthop2012; 142:170-8.
[2] Miyawaki S, Koyama I, Inoue M, Mishima K, Sugahara T, Takano-Yamamoto T. Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. Am J OrthodDentofac. 2003; 124:373-8.
[3] Kan CH, BozicM, English J, Lee R, BusaH, Ellis RK. Cone beam computed tomography of the maxillofacial region- an update. Int J. Med Robot 2009;5:366-380
[4] Motoyoshi M, Yoshida T, Ono A, Shimizu N. Effect of cortical bone thickness and implant placement torque on the stability of orthodontic mini-implants. Int J Oral Max Impl. 2007;22:779-84.

[5] Cynthia C.Leung, Leena Palomo, Richard Griffith, and Mark G. Hans. Accuracy and reliability of cone-beam computed tomography for measuring the alveolar bone height and detecting bony dehiscences and fenestrations. Am J Orthod Dentofacial Orthop 2010;137: S109-19
[6] Ingervall B, Thilander B. Relation between facial morphology and activity of the masticatory muscles. J Oral Rehabil1974;1:131-47.
[7] Sato H, Kawamura A, Yamaguchi M, Kasai K. Relationship between masticatory function and internal structure of the mandible based on computed tomography findings. Am J Orthod Dentofacial Orthop2005;128:766-773.
[8] Kohakura S, Kasai K, Ohno I, Kanazawa E. Relationship between maxillofacial morphology and morphological characteristics of vertical sections of the mandible obtained by CT scanning. J Nihon UnivSch Dent 1997;39:71-7.
[9] Schulze D, Heiland M. Thurmann H. Adam G. Radiation exposure during midfacial imaging using 4and 16-slice computed tomography, cone heam computed tomography systems and conventional radiography. DentomaxillofaRadioI2004:33:83-86.
[10] Patrick B. Holmes; Bethany J. Wolb; Jing Zhou. A CBCT atlas of buccal cortical bone thickness in interradicular spaces. Angle Orthod. 2015;85:911–919.
[11] Amr Ragab El-Beialy, Mona Salah Fayed, Ahmed Mohammed El-Bialy, and Yehya A. Mostafa. Accuracy and reliability of cone-beam computed tomography measurements: Influence of head orientation. Am J Orthod Dentofacial Orthop2011;140:157-65
[12] Patcas, R., Muller, L., Ullrich, O., &Peltomaki, T. Accuracy of cone-beam computed tomography at different resolutions assessed on the bony covering of the mandibular anterior teeth. Am J Orthod Dentofacial Orthop 2012; 141(1), 41-50.
[13] AsliBaysal, Faruk IzzetUcar, Suleyman KutalmisBuyuk, Torun Ozer, TancanUysal Alveolar bone thickness and lower incisor position in skeletal Class I and Class II malocclusions assessed with cone-beam computed tomography. Korean J Orthod 2013;43(3):134-140.
[14] Frost HM. The mechanostat: a proposed pathogenic mechanism of osteoporoses and the bone mass effects of mechanical and nonmechanical agents. Bone and Miner. 1987;2:73-85.
[15] Ono A, Motoyoshi M, Shimizu N. Cortical bone thickness in the buccal posterior region for orthodontic mini-implants. Int J Oral Maxillofac Surg. 2008;37:334-40.
[16] Deguchi T, Nasu M, Murakami K, Yabuuchi T, Kamioka H, Takano-Ymaoto T. Quantitative evaluation of cortical bone thickness with computed tomographic scanning for orthodontic implants. Am J Orthod Dentofacial Orthop. 2006;129:721.e7-12.
[17] David Farnsworth, P.Emile Rossouw, Richard F Ceen&Peter Buschang. Crtical bone thickness at common mini screw implant sites. Am J Orthod Dentofacial Orthop2011;139:495-503
[18] Park HM, Kim BH, Yang IH, Baek SH. Preliminary three-dimensional analysis of tooth movement and arch dimension change of the maxillary dentition in Class II division 1 malocclusion treated with first premolar extraction: conventional anchorage vs. mini-implant anchorage. Korean J Orthod 2012; 42:280-90.
[19] Schätzle M, Männchen R, Zwahlen M, Lang NP. Survival and failure rates of orthodontic temporary anchorage devices: a systematic review. Clin Oral Implants Res 2009;20:1351-9.
[20] Moyoshi M, UemuraM, Okazaki K, Shigeeda T, Shimizu N. Factors affecting the long term stability of orthodontic mini implants. Am J Orthod Dentofacial Orthop 2010;137:588-593.
[21] Santiago RC, de Paula FO, FragaMR, Picorelli Assis NM, Vitral RW. Correlation between miniscrew stability and bone mineral density in orthodontic patients. Am J Orthod Dentofacial Orthop2009; 136:243-250.
[22] Wilmes B, Rademacher C, Olthoff G, Drescher D. Parameters affecting the primary stability of orthodontic mini-implants. J OrofacOrthop2006;67:162–174.
[23] Bjork, A., &Skieller, V. Facial development, and tooth eruption: an implant study at the age of puberty. Am J Orthod 1972; 62(4), 339-383.
[24] Peter H. Buschang, Helder Jacob, Roberto Carrillo; The morphological characteristics, growth, and etiology of the hyperdivergent phenotype. Seminars in orthodontics: December 2013; Vol 19; Issue 4; Pages 212-226.
[25] Masumoto, T., Hayashi, I., Kawamura, A., Tanaka, K., & Kasai, K. Relationships among facial type, buccolingual molar inclination, and cortical bone thickness of the mandible. Eur J Orthod2001; 23(1), 15-23.
[26] Tsunori, M., Mashita, M., & Kasai, K. Relationship between facial types and tooth and bone characteristics of the mandible obtained by CT scanning. Angle Orthod1998; 68(6), 557-562.
[27] Jin Hwan Choi, HyungSeog Yu, Kee Joon Lee, Young Chel Park: Three-dimensional evaluation of maxillary anterior alveolar bone for optimal placement of miniscrew implants: Korean J Orthod 2014;44(2):54-61
[28] Swasty, D., Lee, J., Huang, J. C., Maki, K., Gansky, S. A., Hatcher, D., & Miller, A. J. Cross-sectional human mandibular morphology as assessed in vivo by cone-beam computed tomography in patients with different vertical facial dimensions Am J Orthod Dentofacial Orthop 2011; 139(4 Suppl), e377-89.
[29] Kiliaridis S, Mejersjö C, Thilander B. Muscle function and craniofacial morphology: a clinical study in patients with myotonic dystrophy. Eur J Orthod. 1989;11:131-8.
[30] Menegaz RA, Sublett SV, Figueroa SD, Hoffman TJ, Ravosa MJ. Phenotypic plasticity and function of the hard palate in growing rabbits. Anat Rec (Hoboken). 2009;292:277-84.
[31] Bresin A, Kiliaridis S, Strid KG. Effect of masticatory function on the internal bone structure in the mandible of the growing rat. Eur J Oral Sci. 1999;107:35-44.
[32] Farman, A., Scarfe, W. (2009. The basics of maxillofacial cone beam computed tomography. Seminars in Orthodontics, 15(1), 2-13.
[33] Mavropoulos A, Bresin A, Kiliaridis S. Morphometric analysis of the mandible in growing rats with different masticatory functional demands: adaptation to an upper posterior bite block. Eur J Oral Sci. 2004;112:259-66.
[34] Moon CH, Park HK, Nam JS, Im JS, Baek SH. The relationship between vertical skeletal pattern and success rate of orthodontic miniimplants. Am J Orthod Dentofacial Orthop2010;138:51-7.

[35] Manni A, Cozzani M, Tamborrino F, De Rinaldis S, Menini A. Factors influencing the stability of miniscrews. A retrospective study on 300 miniscrews. Eur J Orthod2011;33:388-95

[36] Lim WH, Lee SK, Wikesjo UM, Chun YS. A descriptive tissue evaluation at maxillary interradicular sites: implications of orthodontic mini-implant placement. Clin Anat2007;20:760-5.

[37] Baumgaertel S, Hans MG. Buccal cortical bone thickness for miniimplant placement. Am J Orthod Dentofacial Orthop 2009;136: 230-5.

[38] Kim HJ, Yun HS, Park HD, Kim DH, Park YC. Soft-tissue and cortical-bone thickness at orthodontic implant sites. Am J Orthod Dentofacial Orthop2006;130:177-82.

