Introduction

Orthodontic mini-implants have been incorporated into orthodontic treatment modalities. Adequate bone at mini-implant placement site can influence the success or failure of anchorage. The present study was to determine the thickness of cortical bone in the maxillary mid-palatal area at predetermined points for the placement of orthodontic mini-implants using Cone Beam CT technique in order to evaluate the relationship of these values with the facial height.

Materials and Methods

A total of 161 patients, consisting of 63 males (39.13%) and 98 females (60.87%), were evaluated in the present study; 38% of the subjects had normal facial height, 29% had short face and 33% had long face. In order to determine which patient belongs to which facial height category, i.e. normal, long or short, two angular and linear evaluations were used: the angle between S-N and Go-Me lines and the S-Go/N-Me ratio. Twenty points were evaluated in all the samples. First the incisive foramen was located. The paracoronal cross-sections were prepared at distances of 4, 8, 16 and 24 mm from the distal wall of the incisive foramen and on each cross-section the mid-sagittal and para-sagittal areas were determined bilaterally at 3- and 6-mm distances (a total of 5 points). The thicknesses of the cortical plate of bone were determined at the predetermined points.

Results

There was a significant relationship between the mean cortical bone thickness and facial height (P<0.01), with significantly less thickness in long faces compared to short faces. However, the thickness of cortical bone in normal faces was similar to that in long and short faces. Separate evaluation of the points showed that at point a16 subjects with short faces had thicker cortical bone compared to subjects with long and normal faces. At point b16 in long faces, the thickness of the cortical bone was significantly less than that in short and normal faces. At point d8, the thickness of the cortical bone in subjects with short faces was significantly higher than that in subjects with long faces.

Conclusion

At the point a16 the cortical bone thickness in short faces was significantly higher than normal and long faces. The lower thickness of the cortical bone in the palatal area at points b16 and d8 in subjects with long faces might indicate a lower anchorage value of these points in these subjects.

Keywords: Anchorage, cone beam computed tomography, cortical bone thickness, facial height.

Since the facial height is related to morphologic changes induced by genetics and oral breathing during childhood, it is rational that the thickness of bone in patients with different facial heights will be different [10-11]. In a clinical study, one of the parameters determining the success of mini-implants was reported to be the facial height [12].

The aim of the present study was to determine the thicknesses of cortical bone in the mid-palatal area of the maxilla with the use of Cone beam CT technique in patients with different facial heights. Such a study with this sample size has not been carried out to date and the present study was carried out in a population of Iranian patients, referred to the Department of Radiology, Faculty of Dentistry, Tabriz University of Medical Sciences.

Materials and Methods

The present descriptive study was carried out on Cone beam CT images of patients referred to the Department of Radiology, Tabriz Faculty of Dentistry, in 2013-2014. The inclusion criteria consisted of all the patients referred to the Radiology Department for any reasons necessitating Cone beam CT imaging, with favorable image quality. The exclusion criteria consisted of the following: malformations or syndromes, anomalies with potential effects on facial height, syndromes, anomalies with potential effects on facial height, syndromes, anomalies with potential effects on facial height, syndromes, anomalies with potential effects on facial height.
systemic diseases, history of trauma and surgery of the study area, patients in the mixed dentition period and presence of impacted teeth in the palatal area.

The Cone beam CT images of all the subjects were taken using a NewTom VGI Cone beam CT unit with the following specifications: 15×15-cm field of view; 110 kVp, 1-20 mA, scan time = 18 seconds and voxel size: 0.3 mm. Then the images were reconstructed with NNT viewer software. Twenty points were evaluated in all the samples (Fig. 1).

Fig. (1). Reference points and lines for measuring the bone thicknesses.

First, the incisive foramen was located by placing the sagittal and axial views next to each other. The para-coronal cross-sections were prepared at 4-, 8-, 16- and 24-mm distances, respectively, from the posterior wall of the incisive foramen. On each cross-section, the mid-sagittal and parasagittal areas were determined bilaterally at 3- and 6-mm intervals (5 points on the whole) (Fig. 2). At the pre-determined areas the thicknesses of cortical bone were determined (Fig. 3). All the measurements were made perpendicular to the tissue surface, in mm.

Fig. (2). Reconstructed coronal cross-sections at 24-, 16-, 8- and 4-mm distances distal to the posterior wall of the incisive foramen.

The images were displayed on a 19-inch Philips LCD (liquid crystal display) monitor of a desktop computer, with a resolution of 1024 ×1024 and 32-bit and visualized by an observer twice with an interval of 2 weeks in a windowless dimly lit room.

Fig. (3). A sample of measurements on each cross-section.

Patients’ lateral views taken as a scout (Fig. 4 and Fig. 5) were used to assign patients to normal, long and short face groups with the use of angular (the angle between Sella-Nasion and Gonion-Menton lines) and linear (the ratio of Sella-Gonion/Nasion-Menton) evaluations. In relation to linear evaluation, subjects in which the Sella-Gonion/Nasion-Menton ratio was less than 61% were assigned to the long face group; subject with a ratio between 61 and 69 percent were assigned to the normal group; and subjects in which this ratio was over 69% were placed in the short face group. In relation to angular evaluation, subjects in which the angle between Sella-Nasion and Gonion-Menton lines was less than 27° were placed in the short face group; subjects with a degree between 27 and 37 were placed in the normal face group; and patients with a degree greater than 37° were placed in the long face group [13].

Fig. (4). Lateral scout view with it’s angular measurements.
Subjects who were placed in two different groups by the angular and linear evaluations were excluded from the study.

Statistical analysis were carried out with software SPSS 171-way analysis of variance was used for intergroup comparisons, and Tukey’s Honestly significant difference (HSD) tests was used for subgroup comparisons.

Cronbach’s alpha was used to evaluate intra-group correlation to test the validity of the measurement tool. Cronbach’s alpha was calculated for all the 20 points on palatal bone so that the reproducibility of measurements could be determined for evaluation of the accuracy of measurement tool. Alpha values greater than 0.75 indicate the validity of measurement tool, which was >0.75 in the present study for intra-group correlation, indicating that the measurement tool was adequately accurate for measurements (0.89).

RESULTS

A total of 63 (39.13%) of the subjects were male and 98 (60.87%) were female. There was almost a uniform distribution of different facial heights, with 38% of the subjects with normal face, 29% with short face and 33% with long face.

In the present study, the thickness of cortical bone was determined at 20 points in the palate and the relationship between cortical bone thickness at these points with the facial height was evaluated; only at 3 points a definite statistical relationship was established. There are few number of studies available on the relationship between cortical bone thickness and the facial height and none of these studies evaluated the relationship between the facial height and cortical bone thickness of maxillary palatal bone.

Ozdemir et al. [13] evaluated the mandibular buccal, maxillary buccal and the alveolar bone of maxillary palate and reported that in all the areas measured in low angle cases cortical bone thickness was clearly higher than that in high angle cases. Tsunori et al. [19] and of Masumoto et al. [20] carried out studies on Asian cadavers and reported a relationship between facial type and the thickness of mandibular cortical bone. They carried out measurements only in the mandible. The discrepancies between the results of different studies might be attributed to factor such as differences in racial traits, evaluations on live subjects or on dry skulls and differences in measurement points.

In the present study the thickness of the cortical bone in the palatal area was measured at 20 points using Cone beam CT technique, similar to other studies, because it is important to correctly and precisely determine cortical bone thickness for the success of mini-implants. Masumoto et al. [20] measured 10 points in the mandible and showed that some of
Table 1. Comparison of cortical bone thickness at the predetermined points in terms of facial height.

|                  | Normal | Short | Long | ANOVA       |
|------------------|--------|-------|------|-------------|
|                  | Mean± SD | Mean± SD | Mean± SD | f   | p value   |
| a4               | 1.66±0.60 | 1.66±0.54 | 1.69±0.54 | 0.07 | 0.93      |
| a8               | 1.39±0.45 | 1.53±0.53 | 1.31±0.38 | 3.05 | 0.05      |
| a16              | 1.3±0.43  | 1.52±0.53 | 1.29±0.45 | 3.53 | 0.03      |
| a24              | 1.38±0.52 | 1.36±0.43 | 1.3±0.42  | 0.43 | 0.65      |
| b4               | 1.46±0.48 | 1.43±0.57 | 1.33±0.40 | 1.06 | 0.35      |
| b8               | 1.22±0.32 | 1.19±0.33 | 0.97±0.41 | 2.86 | 0.06      |
| b16              | 1.05±0.41 | 1.17±0.41 | 0.97±0.41 | 3.24 | 0.041     |
| b24              | 1.06±0.44 | 1.14±0.41 | 1.06±0.44 | 0.61 | 0.55      |
| c4               | 1.57±0.54 | 1.54±0.64 | 1.51±0.52 | 0.16 | 0.85      |
| c8               | 1.1±0.42  | 1.06±0.41 | 0.94±0.26 | 2.99 | 0.05      |
| c16              | 0.78±0.36 | 0.83±0.36 | 0.71±0.25 | 1.74 | 0.18      |
| c24              | 0.67±0.30 | 0.71±0.32 | 0.65±0.27 | 0.47 | 0.62      |
| d4               | 1.55±0.56 | 1.52±0.60 | 1.41±0.45 | 0.92 | 0.04      |
| d8               | 1.13±0.40 | 1.22±0.48 | 1.02±0.34 | 3.08 | 0.04      |
| d16              | 1.04±0.37 | 1.12±0.46 | 0.96±0.31 | 2.15 | 0.12      |
| d24              | 1.08±0.45 | 1.09±0.55 | 1±0.33   | 0.66 | 0.52      |
| e4               | 1.53±0.56 | 1.53±0.58 | 1.73±0.69 | 1.86 | 0.16      |
| e8               | 1.02±0.38 | 1.04±0.39 | 1.04±0.36 | 0.07 | 0.94      |
| e16              | 0.79±0.37 | 0.88±0.42 | 0.71±0.29 | 2.49 | 0.09      |
| e24              | 0.67±0.29 | 0.72±0.40 | 0.65±0.27 | 0.66 | 0.52      |
| Cortical bone thickness | 1.17±0.53 | 1.21±0.55 | 1.12±0.51 | 7.548 | 0.001 |

Table 2. The results of Tukey’s Honestly significant difference (HSD) tests to evaluate the groups at sample points.

|                  | (I)     | (J)     | p value |
|------------------|---------|---------|---------|
| a16              | Normal  | Long    | 0.733   |
|                  | Normal  | Short   | 0.029   |
|                  | Short   | Long    | 0.015   |
| b4               | Normal  | Long    | 0.022   |
|                  | Normal  | Short   | 0.134   |
|                  | Short   | Long    | 0.043   |
| d4               | Normal  | Long    | 0.127   |
|                  | Normal  | Short   | 0.295   |
|                  | Short   | Long    | 0.015   |
| Cortical bone thickness | Normal  | Long    | 0.05    |
|                  | Normal  | Short   | 0.20    |
|                  | Short   | Long    | <0.001  |
CONCLUSION

At the point a16 the cortical bone thickness in short faces was significantly higher than normal and long faces. The cortical bone thickness was lower at points b8 and d8 in subjects with long faces, which might indicate a lower anchorage value in these areas. Further studies with a great sample size are necessary to evaluate the relationship between the thickness of cortical bone and facial type.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

ACKNOWLEDGEMENTS

Declared none.

REFERENCES

[1] Bernhart T, Freudenthaler J, Dorthbudak O, Bantleon HP, Watzek G. Short epithetic implants for orthodontic anchorage in the para-median region of the palate. Clin Oral Implants Res 2001; 12: 624-31.
[2] Melsen B. Palatal growth studied on human autopsy material. Am J Orthod 1975; 68: 42-54.
[3] Revelo B, Fishman LS. Maturational evaluation of ossification of the midpalatal suture. Am J Orthod Dentofacial Orthop 1994; 105: 288-92.
[4] Schlegel KA, Kinner F, Schlegel KD. The anatomic basis for palatal implants in orthodontics. Int J Adult Orthod Orthognath Surg 2002; 17: 133-9.
[5] Wehrbein H, Merz BR, Diedrich P, Glatzmaier J. The use of palatal implants for orthodontic anchorage. Design and clinical application of the Orthosystem. Clin Oral Implants Res 1996; 7: 410-6.
[6] Kang S, Lee SJ, Ahn SJ, Heo MS, Kim TW. Bone thickness of the palate for orthodontic mini-implant anchorage in adults. Am J Orthod Dentofacial Orthop 2007; 131(Suppl): 574-81.
[7] Gracco A, Lombardo L, Cozzani M, Siciliani G. Quantitative conebeam computed tomography evaluation of palatal bone thickness for orthodontic miniscrew placement. Am J Orthod Dentofacial Orthop 2008; 134: 361-9.
[8] Gracco A, Lombardo L, Cozzani M, Siciliani G. Quantitative evaluation with CBCT of palatal bone thickness in growing patients. Prog Orthod 2006; 7: 164-74.
[9] Tosun T, Keles A, Erverdi N. Method for the placement of palatal implants. Int J Oral Maxillofac Impl 2002; 17: 95-100.
[10] Arun T, Isik F, Sayinsu K. Vertical growth changes after adenoidectomy. Angle Orthodont 2003; 73(2): 146-50.
[11] Tsunori M, Mashita M, Kasai K. Relationship between facial types and tooth and bone characteristics of the mandible obtained by CT scanning. Angle Orthodont 1998; 68(6): 557-62.
[12] Moon CH, Park HK, Nam JS, Im JS, Baek SH. Relationship between vertical skeletal pattern and success rate of orthodontic mini-implants. Am J Orthodon Dentofacial Orthoped 2010; 138(1): 51-7.
[13] Ozdemir F, Tozu M, Germeckakan D. Cortical bone thickness of the alveolar process measured with cone-beam computed tomography in patients with different facial types. Am J Orthodont Dentofacial Orthop 2013; 143(2): 190-6.
[14] Mah J, Hatcher D. Current status and future needs in craniofacial imaging. Orthod Craniofac Res 2003; 6(1): 10-6.
[15] Malt JK, Danforth RA, Bumann A, Hatcher D. Radiation absorbed in maxillofacial imaging with a new dental computed tomography device. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003; 96: 508-13.
[16] Ludlow JB, Davies-Ludlow LE, Brooks SL. Dosimetry of two extraoral direct digital imaging devices: NewTom cone beam CT and Orthophos Plus DS panoramic unit. Dentomaxillofac Radiol Orthopos 2003; 32: 229-34.
[17] Song JE, Um YJ, Kim CS, Choi SH, Cho KS, Kim CK. Thickness of posterior palatal masticatory mucosa: the use of computerized tomography. J Periodontol 2008; 79: 406-12.
[18] Marquezan M, Nojima L, Baratieri C, Alves Junior M, Nojima M. Tomographic mapping of the hard palate and overlying mucosa. Braz Oral Res 2012; 26(1): 36-42.
[19] Tsunori M, Mashita M, Kasai K. Relationship between facial types and tooth and bone characteristics of the mandible obtained by CT scanning. Angle Orthod 1998; 68: 557-62.
[20] 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 Orthod 2001; 23: 15-23.